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From shells and gold to plastic and silicon: a theory of the evolution of money, in the spirit of Keynes

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Keynes Lecture
British Academy
17 October 2007

From shells and gold to plastic and silicon: a theory of the evolution of money, in the spirit of Keynes

John Moore
Edinburgh and LSE

joint work with

Professor Nobuhiro Kiyotaki FBA

formerly London School of Economics
now Princeton University

development of financial system

economic development

development of financial system

economic development

problem: money & financial intermediation
don’t fit into standard framework

development of financial system

economic development

problem: money & financial intermediation
don't fit into standard framework

need to model: LIQUIDITY
& LIQUIDITY PREFERENCE
(Keynes)

two aspects of financial contracting:

- bilateral commitment
- multilateral commitment

two aspects of financial contracting:

- bilateral commitment
- multilateral commitment

both may be limited

limited bilateral commitment:

limit on how much borrower can credibly promise to repay *initial lender*

limited bilateral commitment:

limit on how much borrower can credibly promise to repay *initial lender*

limited multilateral commitment:

limit on how much borrower can credibly promise to repay *any bearer* of the debt

multilateral commitment is harder
than bilateral commitment

– because the initial lender, as an insider, may become better informed about the borrower than outsiders

multilateral commitment is harder
than bilateral commitment

– because the initial lender, as an insider, may become better informed about the borrower than outsiders

$\Rightarrow$ adverse selection in secondary market for debt

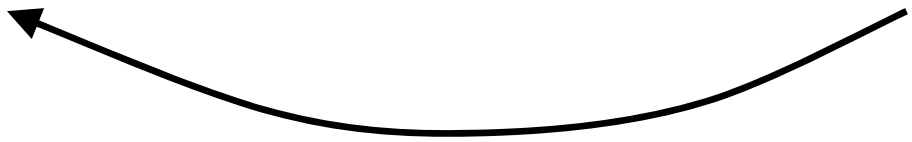
borrower

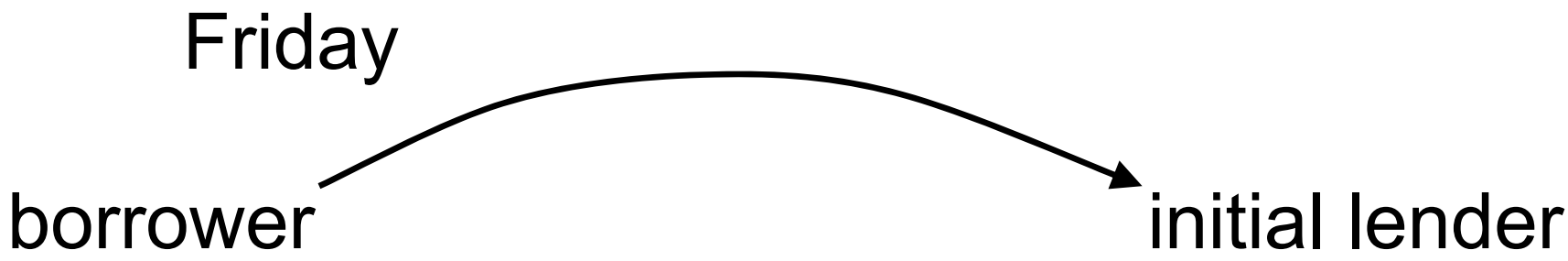
initial lender

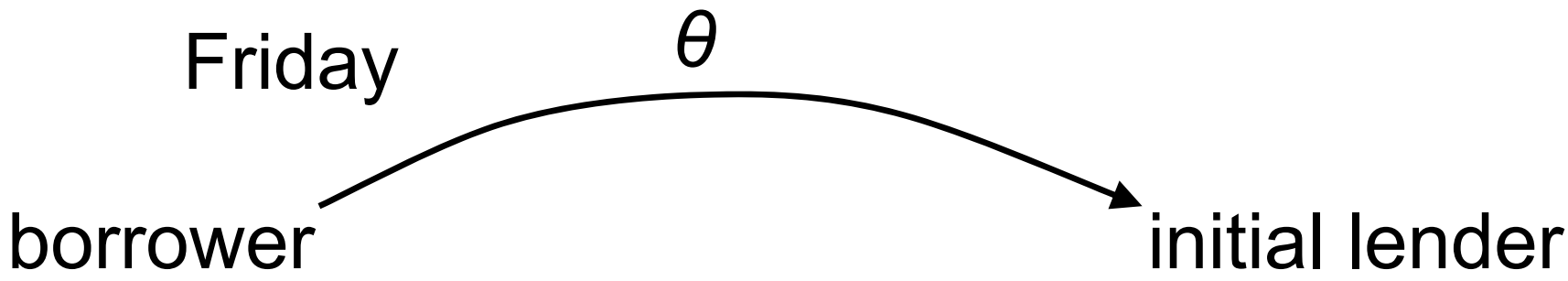
Wednesday

borrower

initial lender

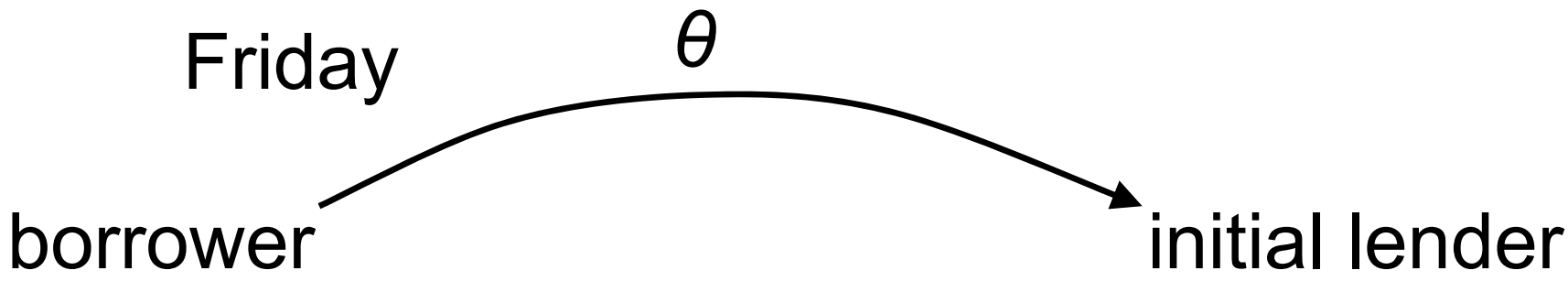



Friday
borrower
initial lender



θ = fraction of output that borrower can credibly commit to repay initial lender

θ *less* than 100%, because of moral hazard



θ = fraction of output that borrower can credibly commit to repay initial lender

θ in part reflects legal structure;
one simple measure of financial depth;
captures degree of "*trust*" in economy

Thursday

borrower

initial lender

Thursday

borrower

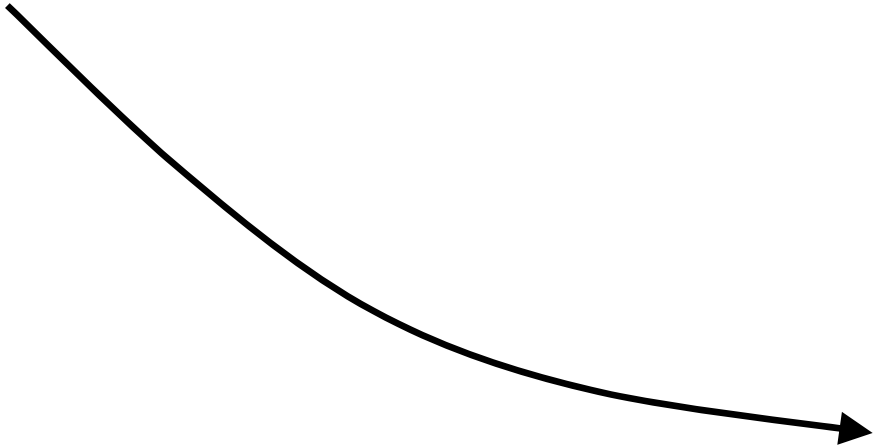
initial lender

new lender

Friday

borrower

initial lender

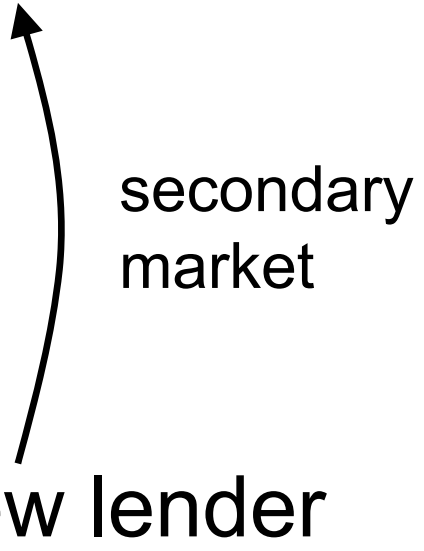


new lender

Thursday

borrower

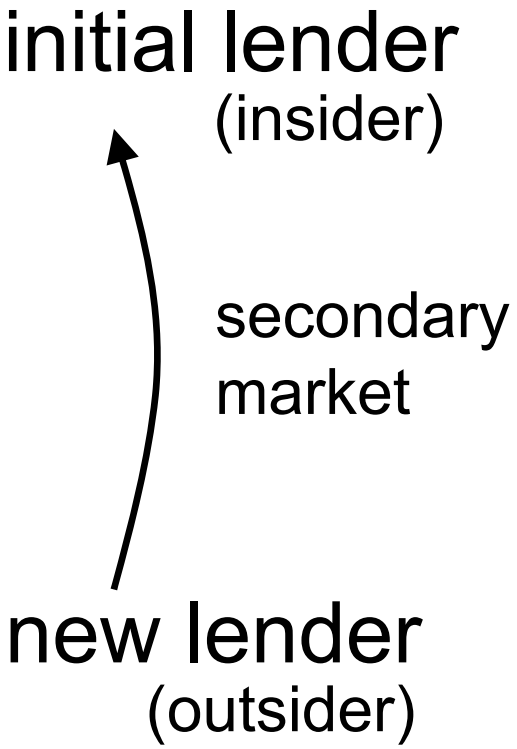
initial lender



new lender

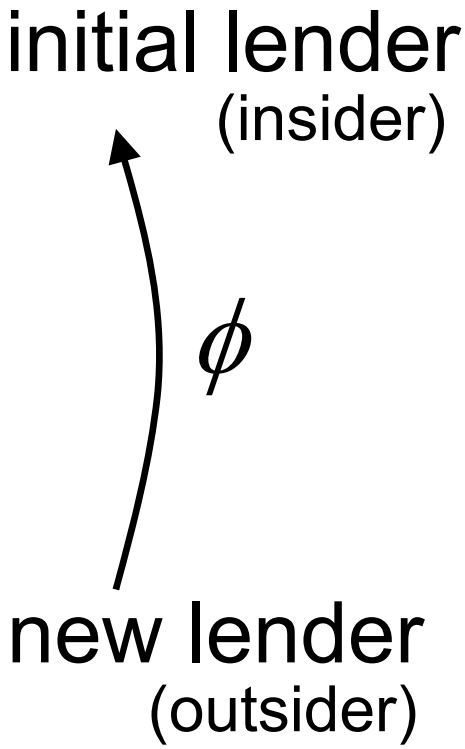
Thursday

borrower



Thursday

borrower



ϕ indexes the efficiency of secondary market;

another simple measure of financial depth;

captures degree of "*liquidity*" in economy

3 types of paper

3 types of paper

blue paper ≡ non-circulating private paper
(sold on Wednesday: but
cannot be resold on Thursday)

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(sold on Wednesday: but
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red paper ≡ circulating private paper
(can be resold on Thursday:
"inside money")

3 types of paper

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(sold on Wednesday: but
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green paper ≡ shells & gold / fiat money
("outside money")

3 types of paper

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Moore
(sold on Wednesday: but
cannot be resold on Thursday)

red paper ≡ circulating private paper
(can be resold on Thursday:
"inside money")

green paper ≡ shells & gold / fiat money
("outside money")

3 types of paper

blue paper ≡ non-circulating private paper
Moore
(sold on Wednesday: but
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red paper ≡ circulating private paper
Branson
(can be resold on Thursday:
"inside money")

green paper ≡ shells & gold / fiat money
("outside money")

3 types of paper

blue paper ≡ non-circulating private paper
Moore
(sold on Wednesday: but
cannot be resold on Thursday)

red paper ≡ circulating private paper
Branson
(can be resold on Thursday:
"inside money")

green paper ≡ shells & gold / fiat money
King
("outside money")

mnemonic

blue paper – ice: illiquid

red paper – blood: liquid: circulates around economy

green paper – dollar bills (“greenbacks”)

coming next …

coming next …

A Brief History of Money
(very brief!)

coming next …

A Brief History of Money
(very brief!)

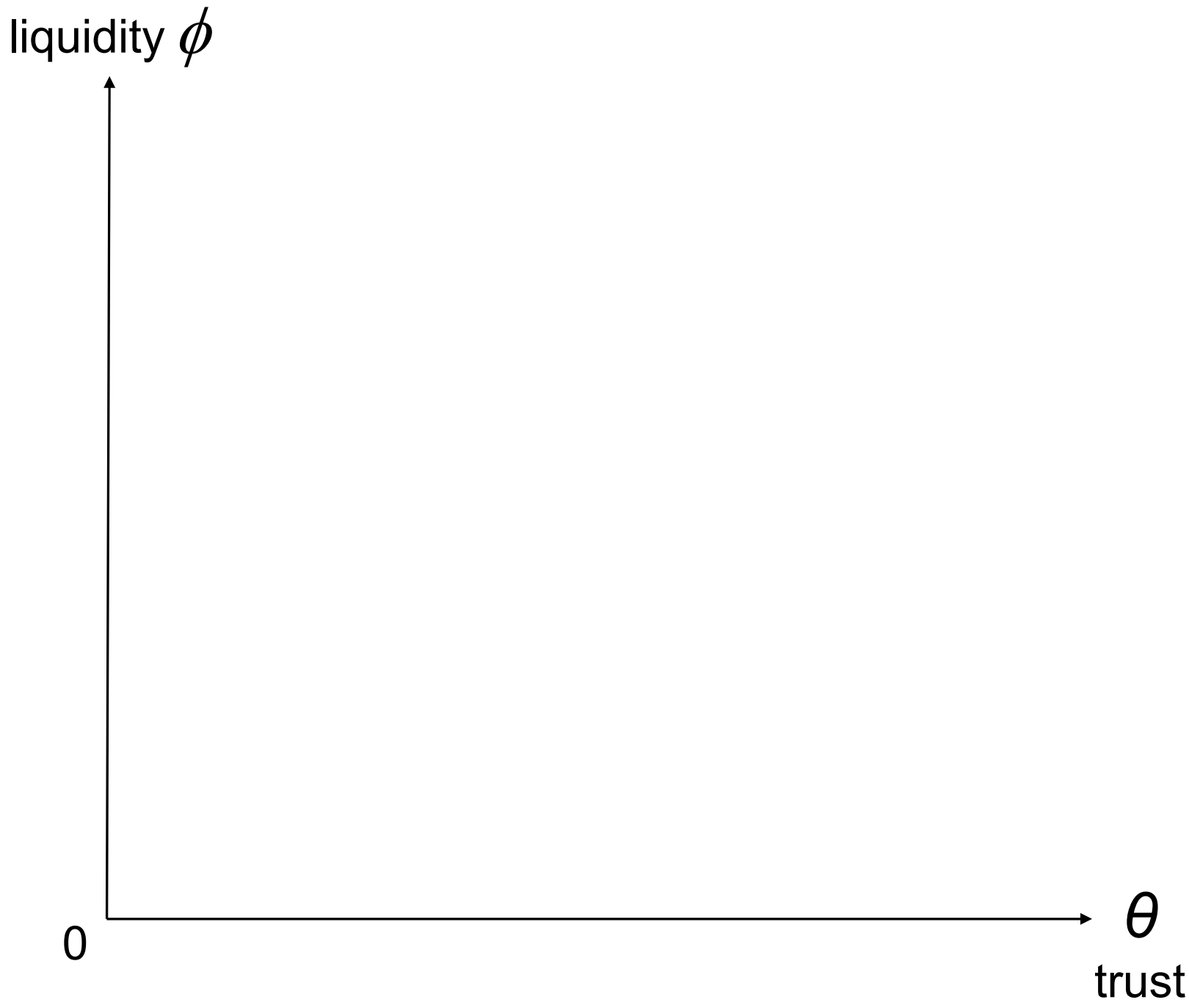
and also …

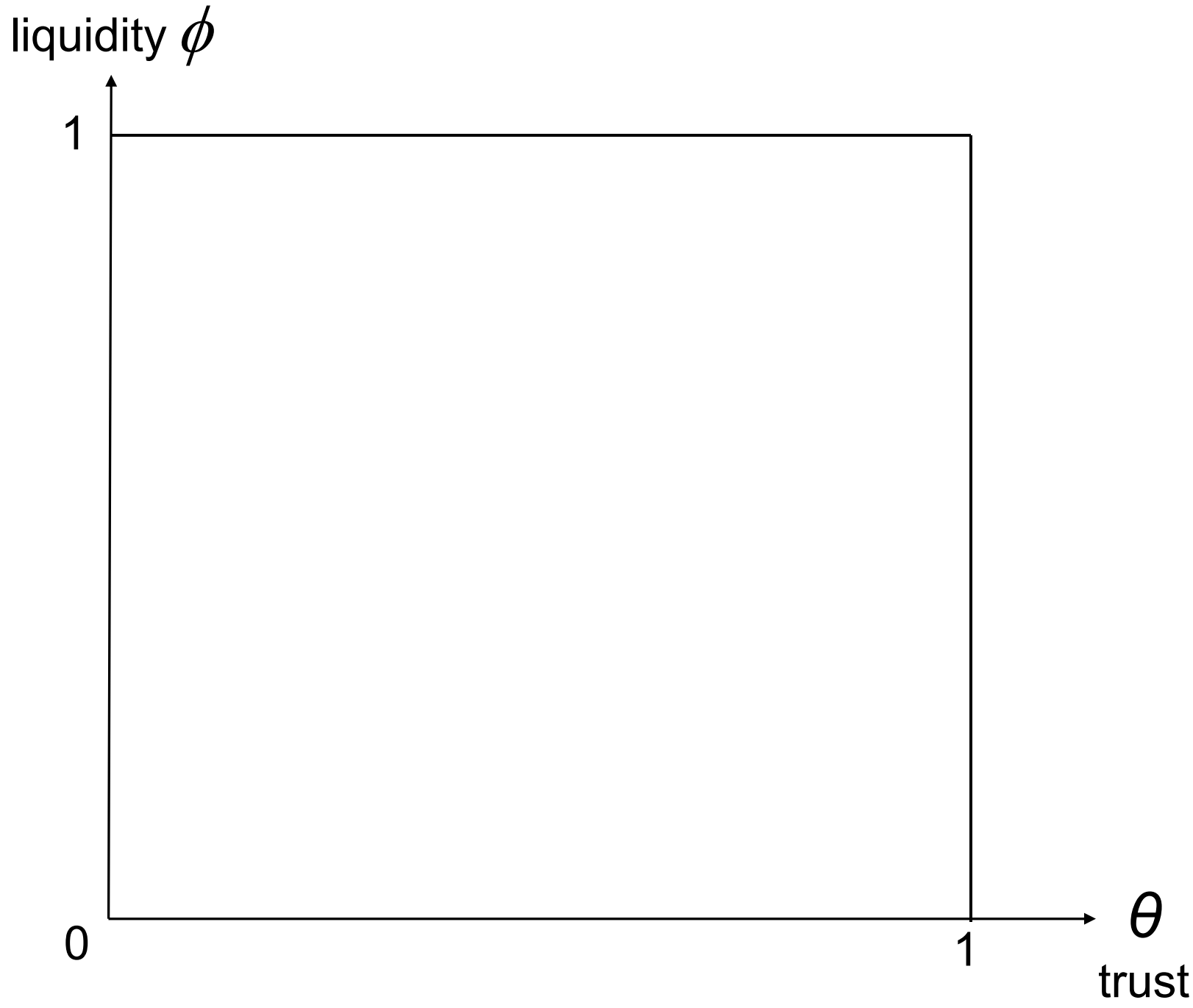
coming next …

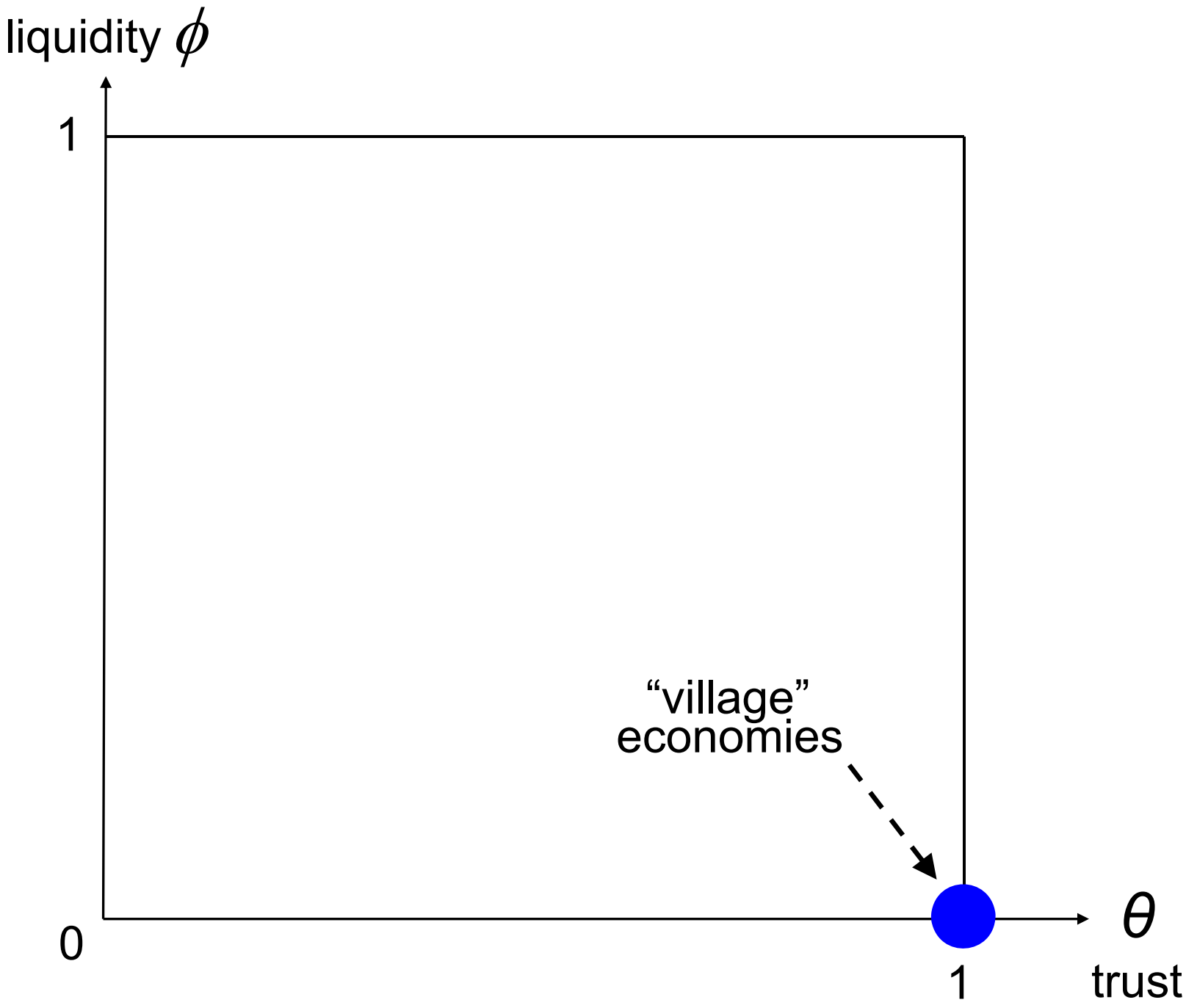
A Brief History of Money
(very brief!)

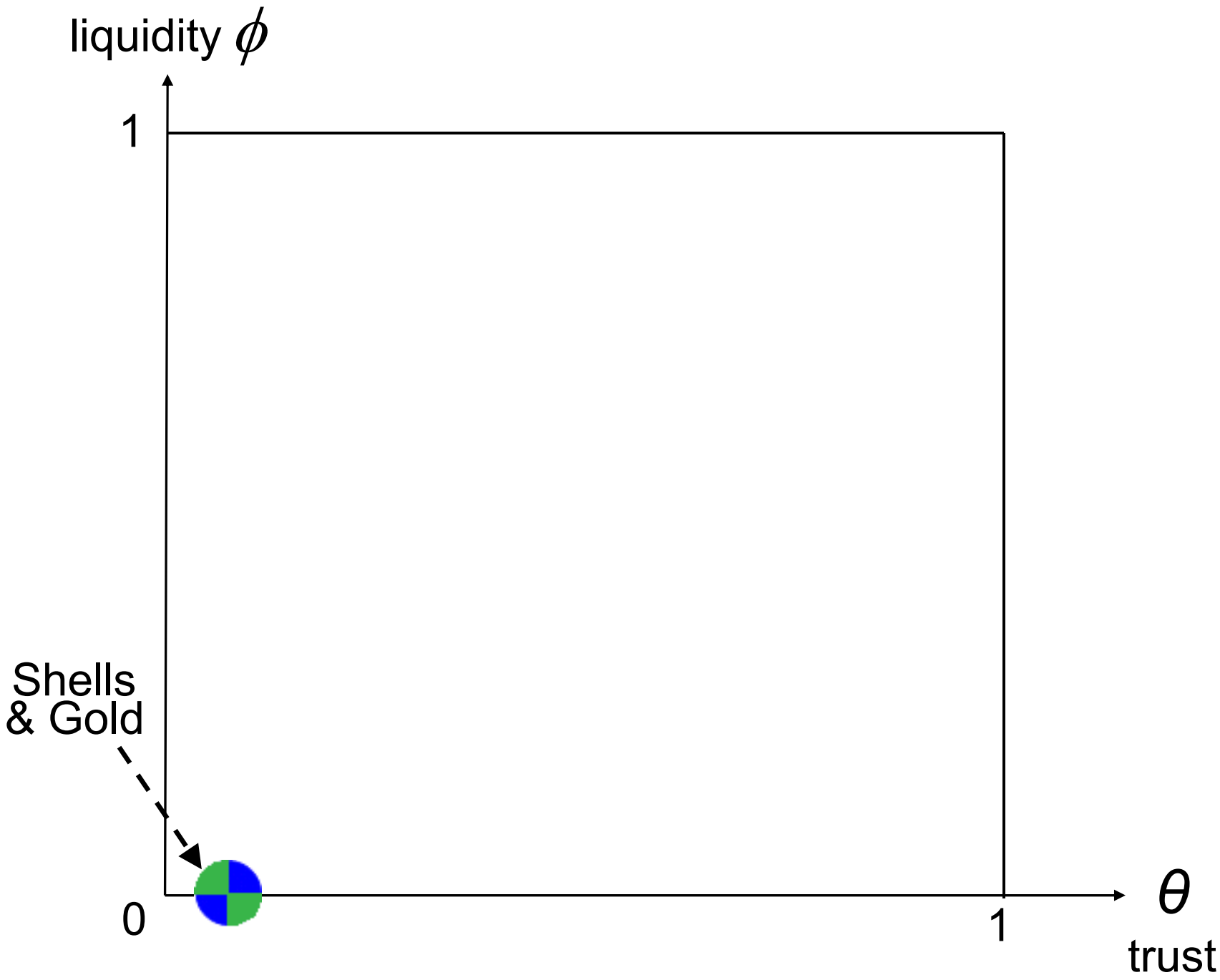
and also …

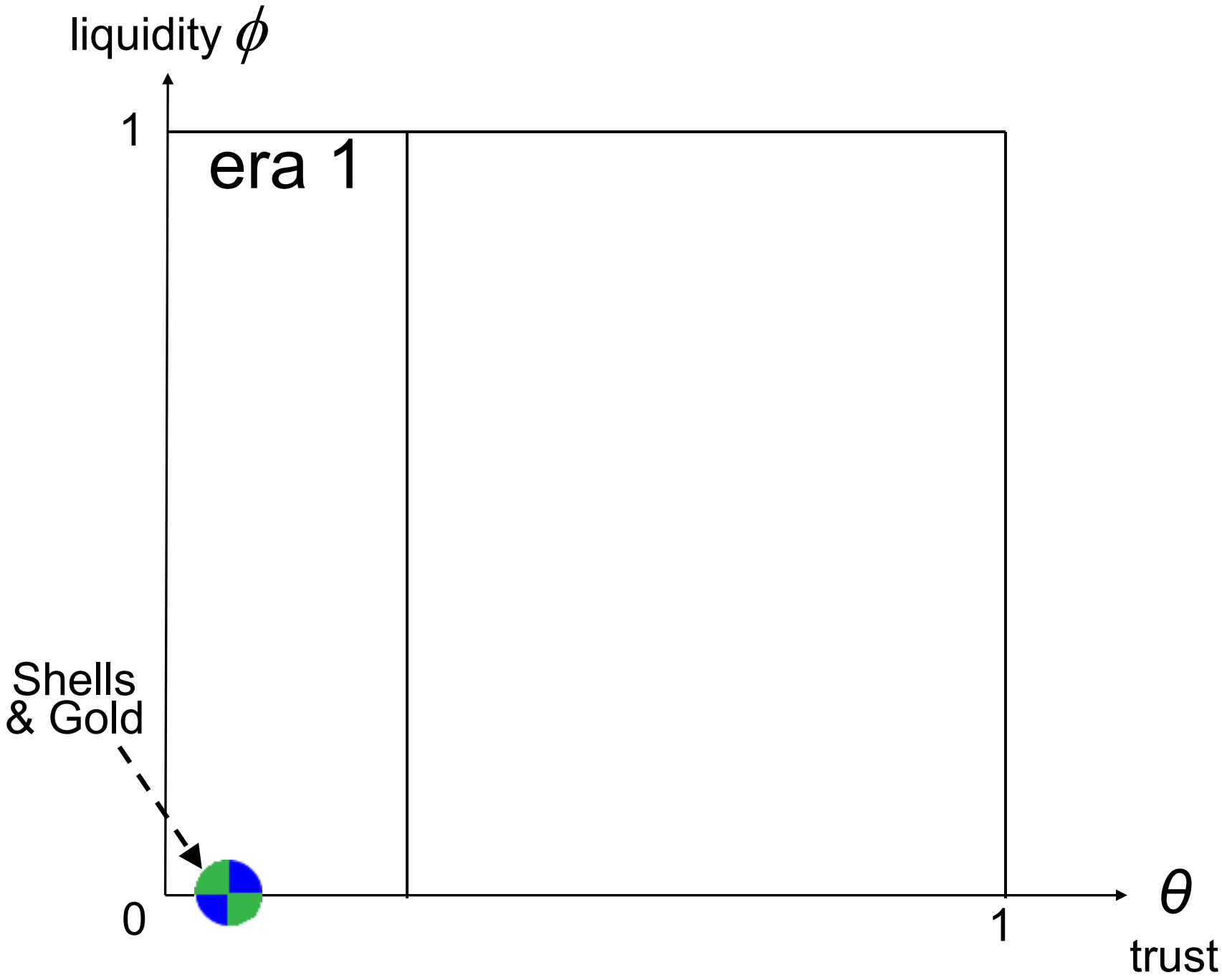
A Vision of the Future
(two visions)

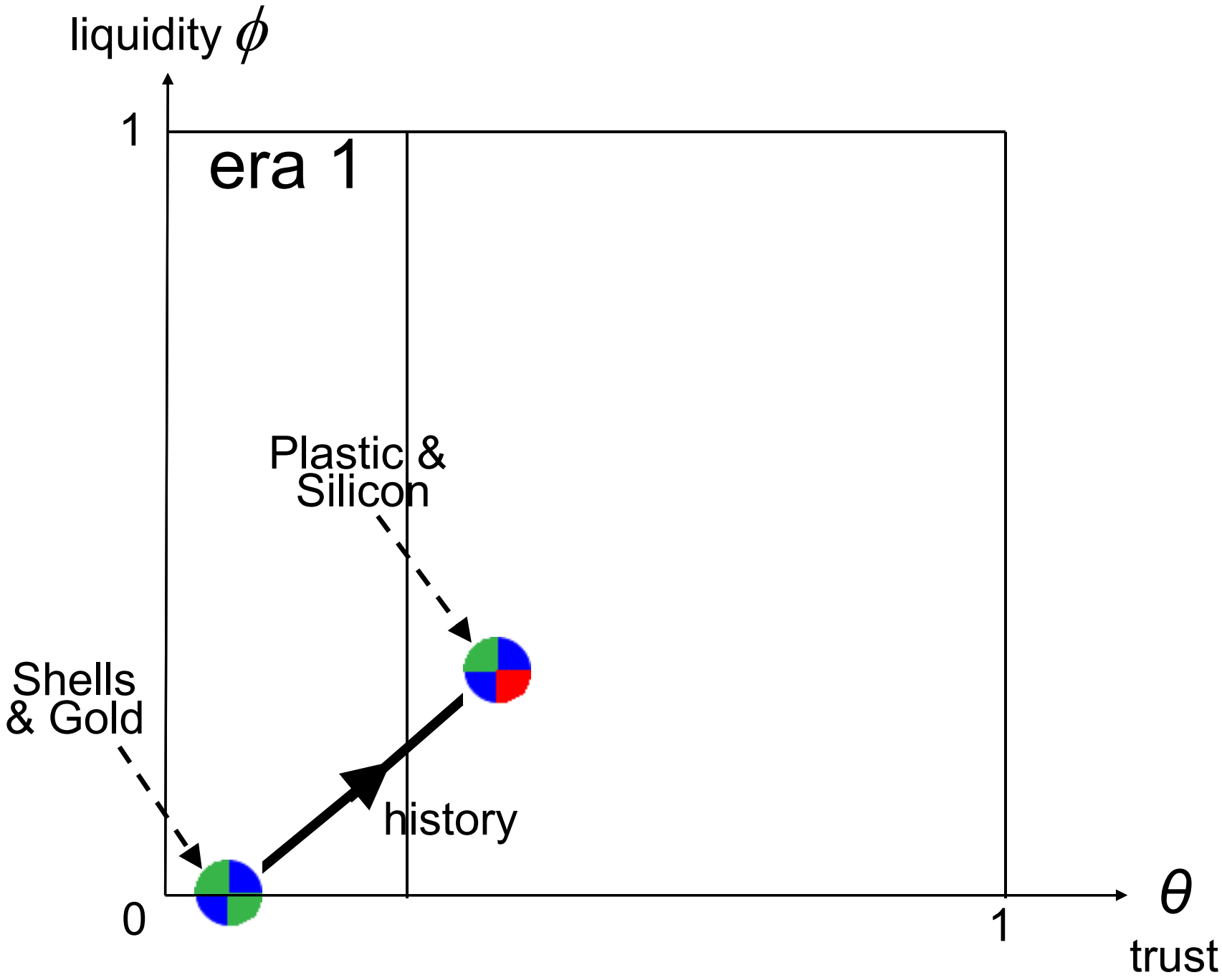

liquidity ϕ
0
θ
trust

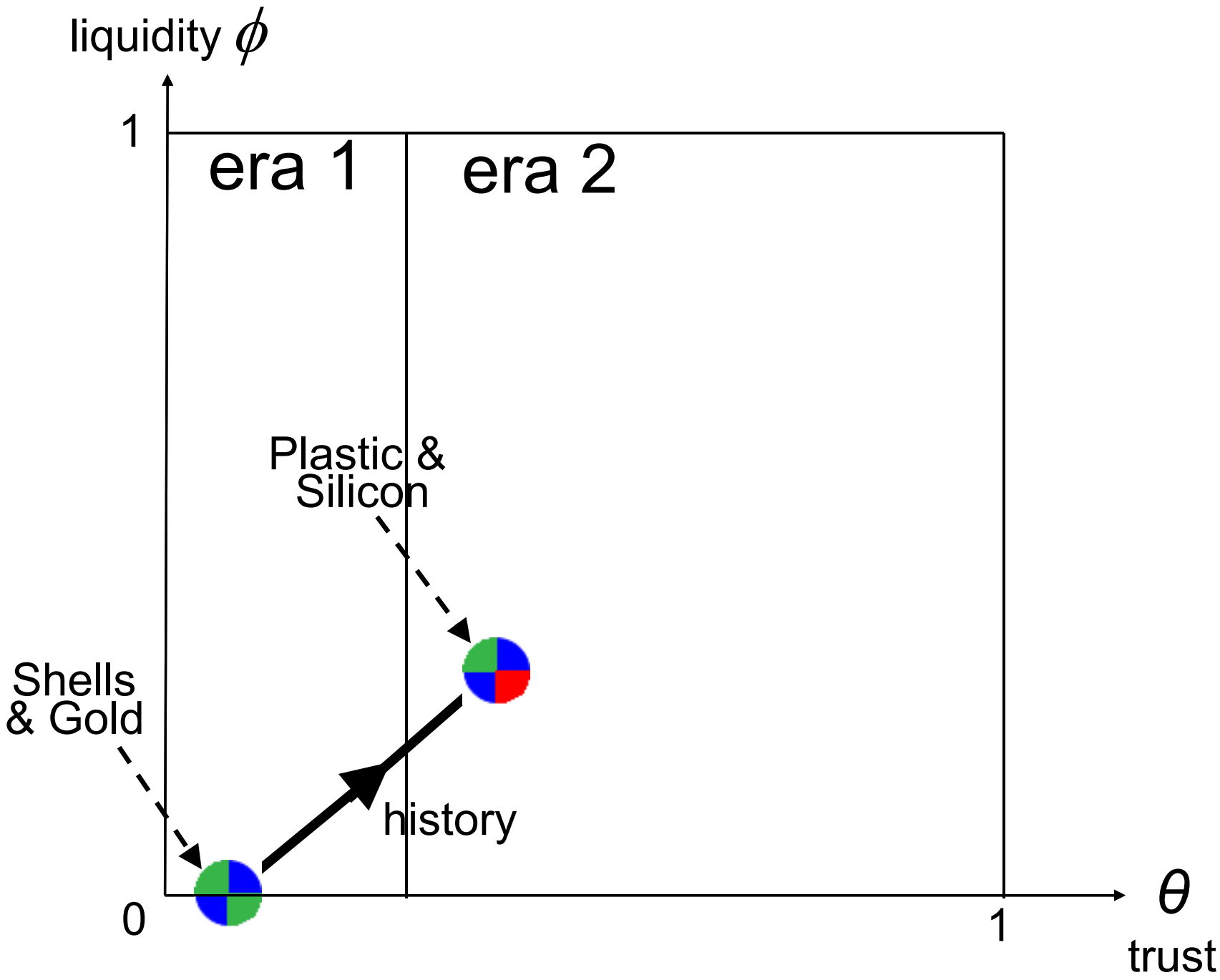

liquidity ϕ
1
0
1
θ
trust


liquidity ϕ
1
0
"village"
economies
1
θ
trust


liquidity ϕ
1
Shells
& Gold
0
1
θ
trust


liquidity ϕ
1
era 1
Shells
& Gold
0
1
θ
trust


liquidity ϕ
1
era 1
Plastic &
Silicon
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
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era 1
era 2
Plastic &
Silicon
Shells
& Gold
history
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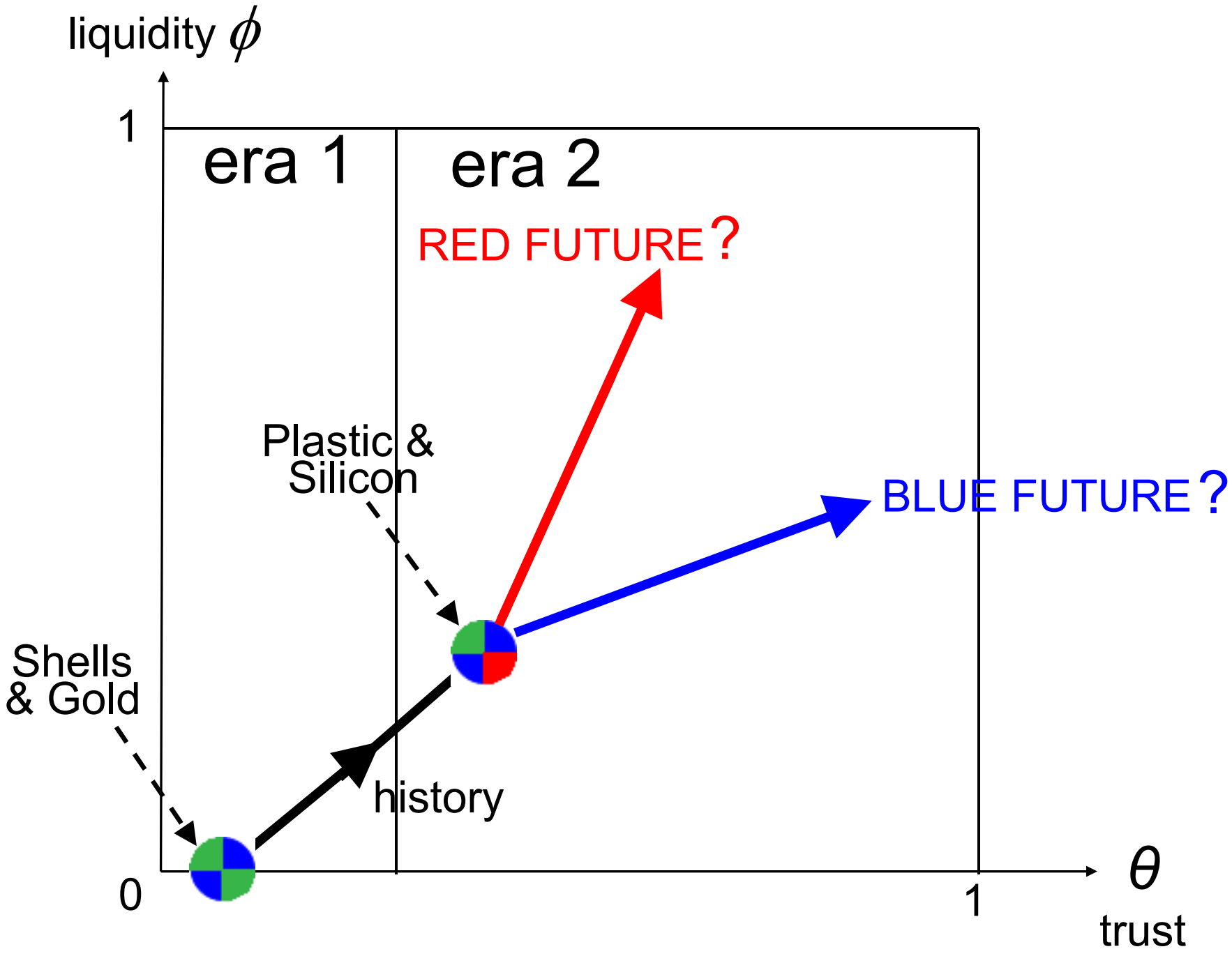
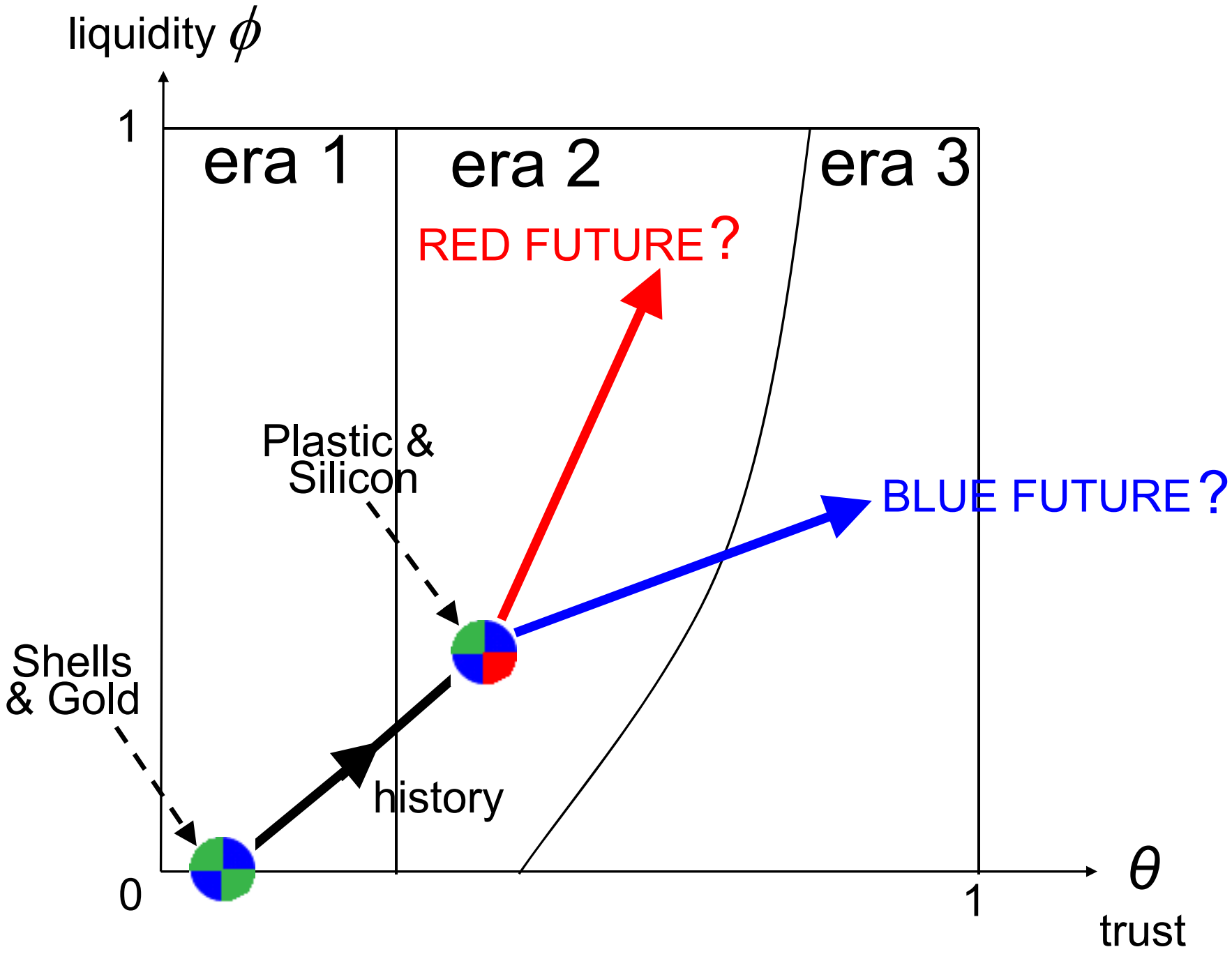
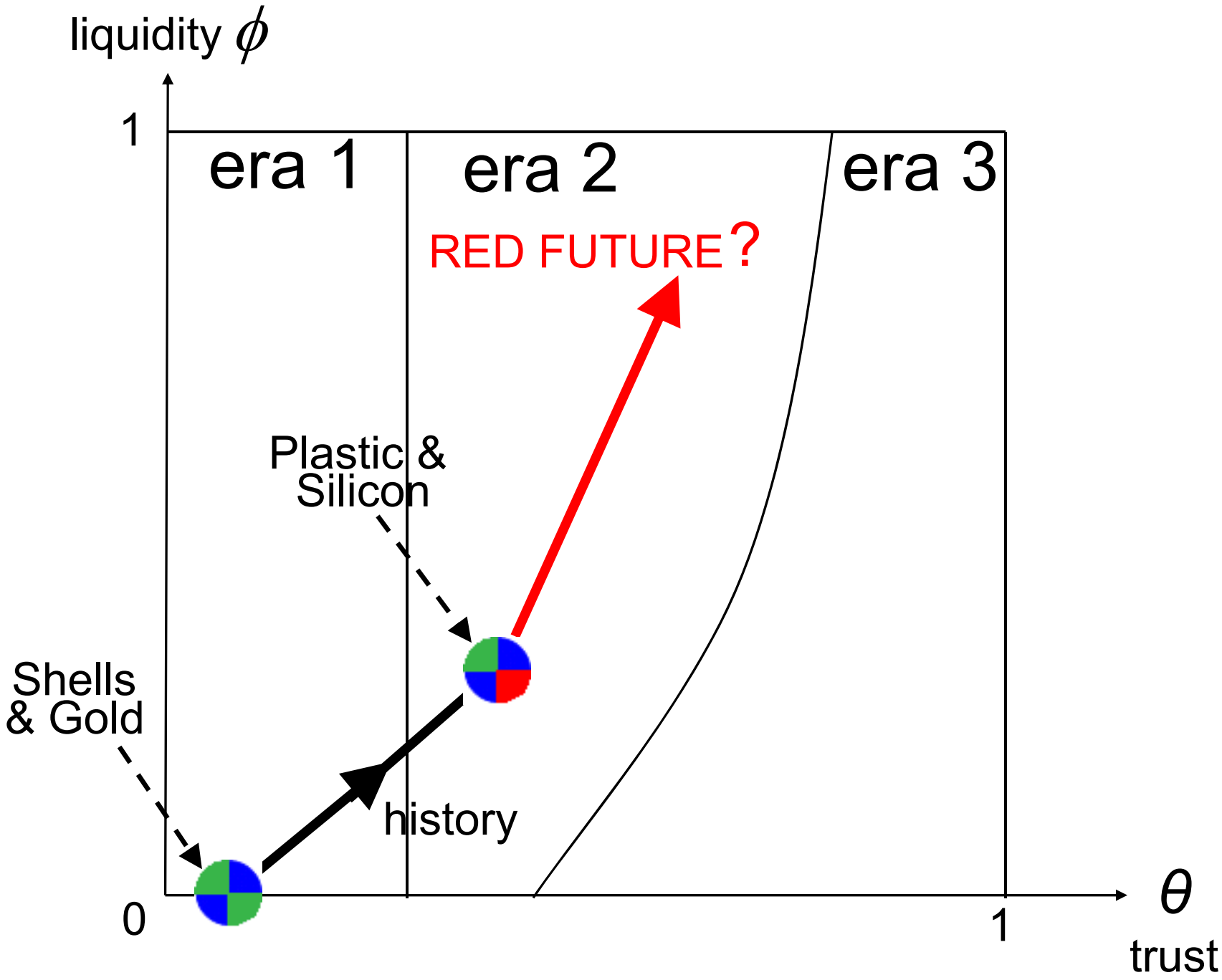
trust


liquidity ϕ
1
era 1
era 2
RED FUTURE?
Plastic &
Silicon
BLUE FUTURE?
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
RED FUTURE?
Plastic &
Silicon
BLUE FUTURE?
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
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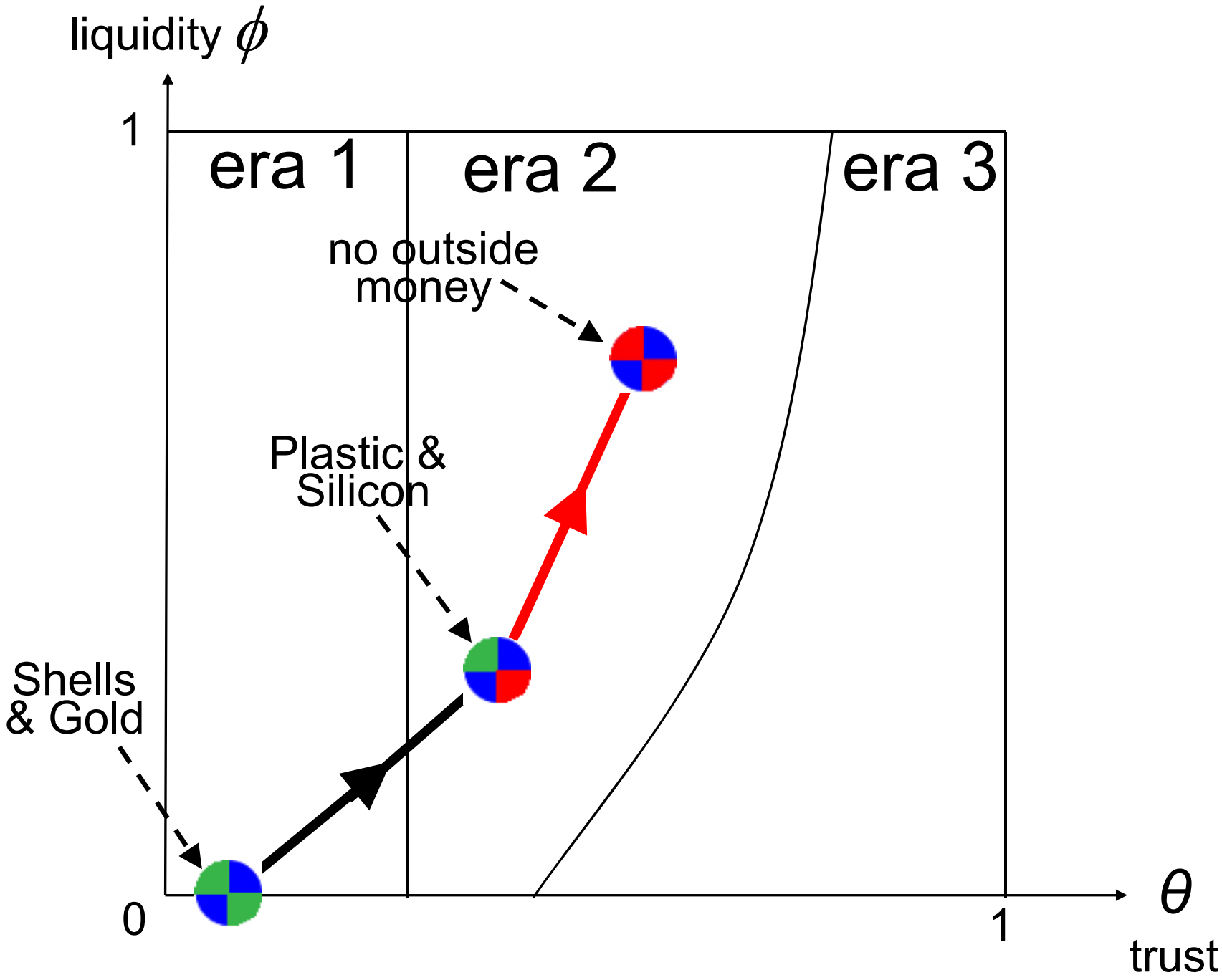
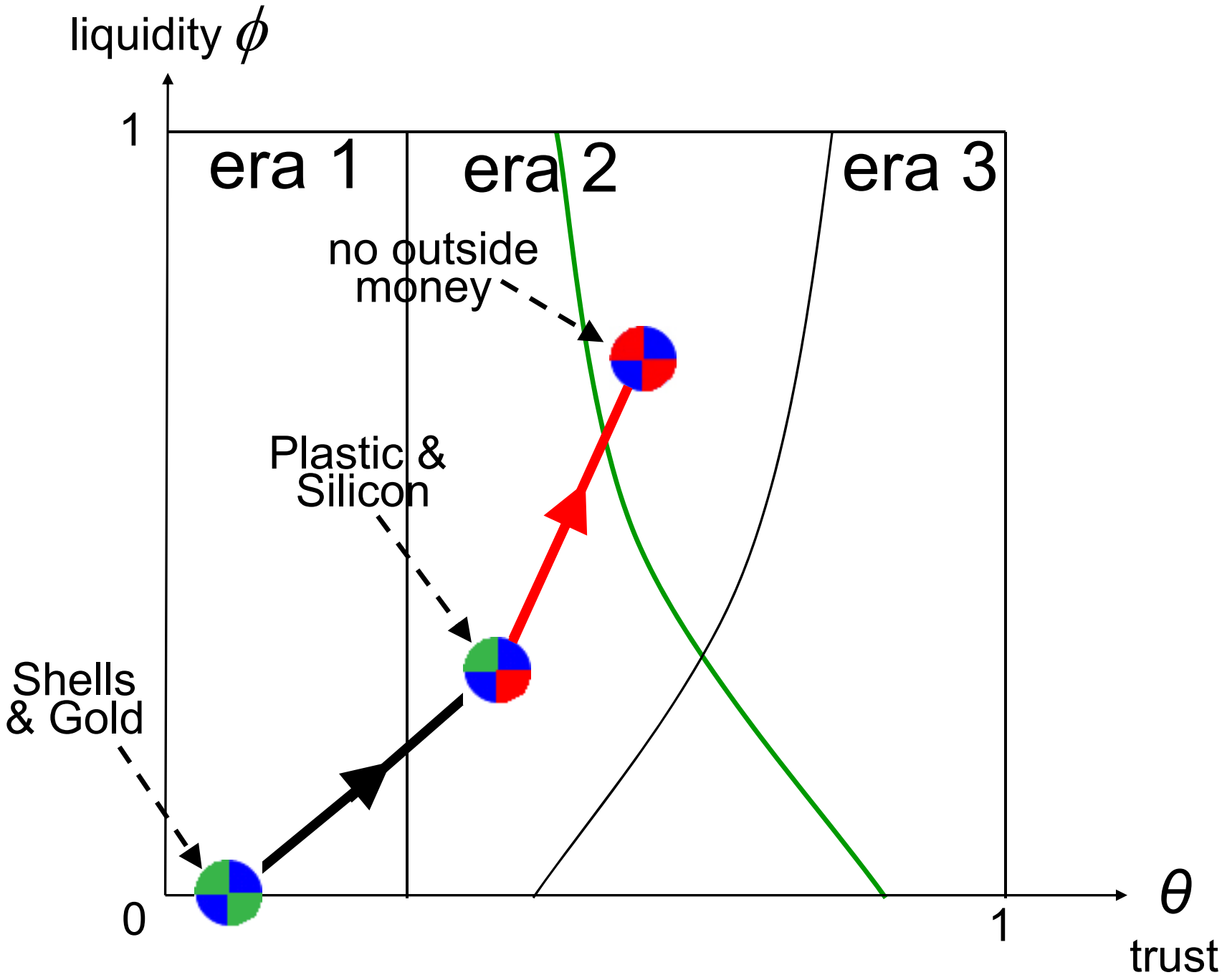
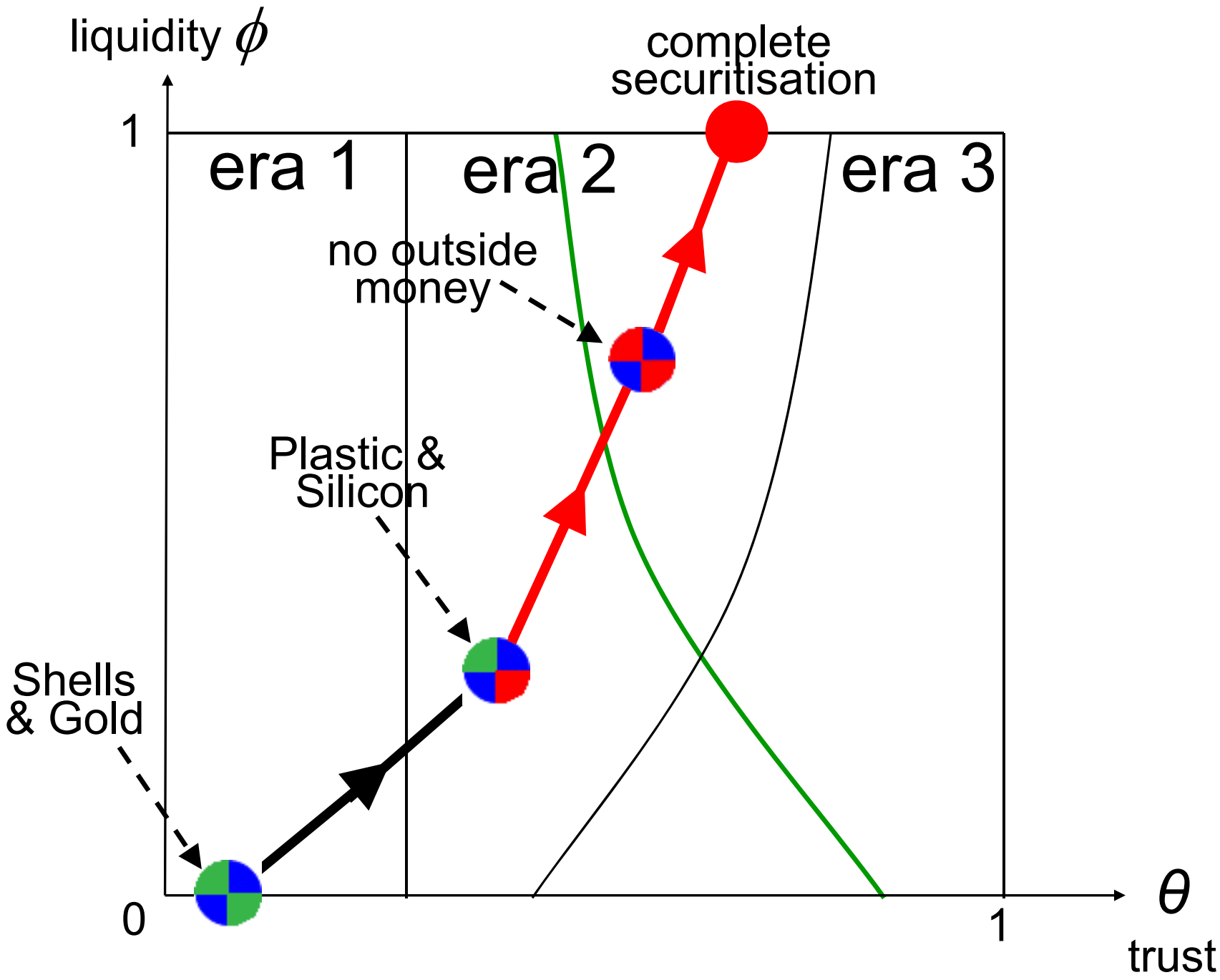
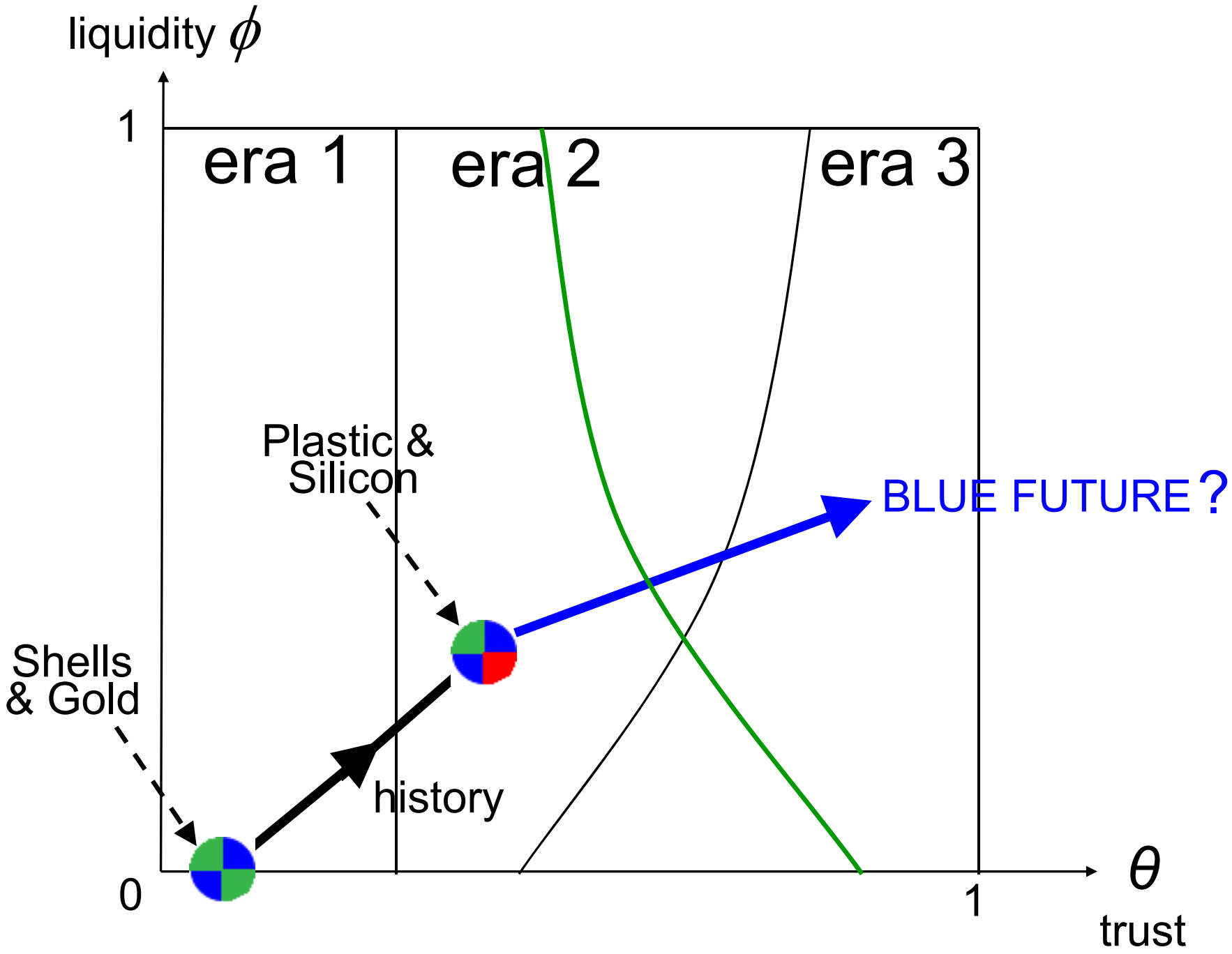
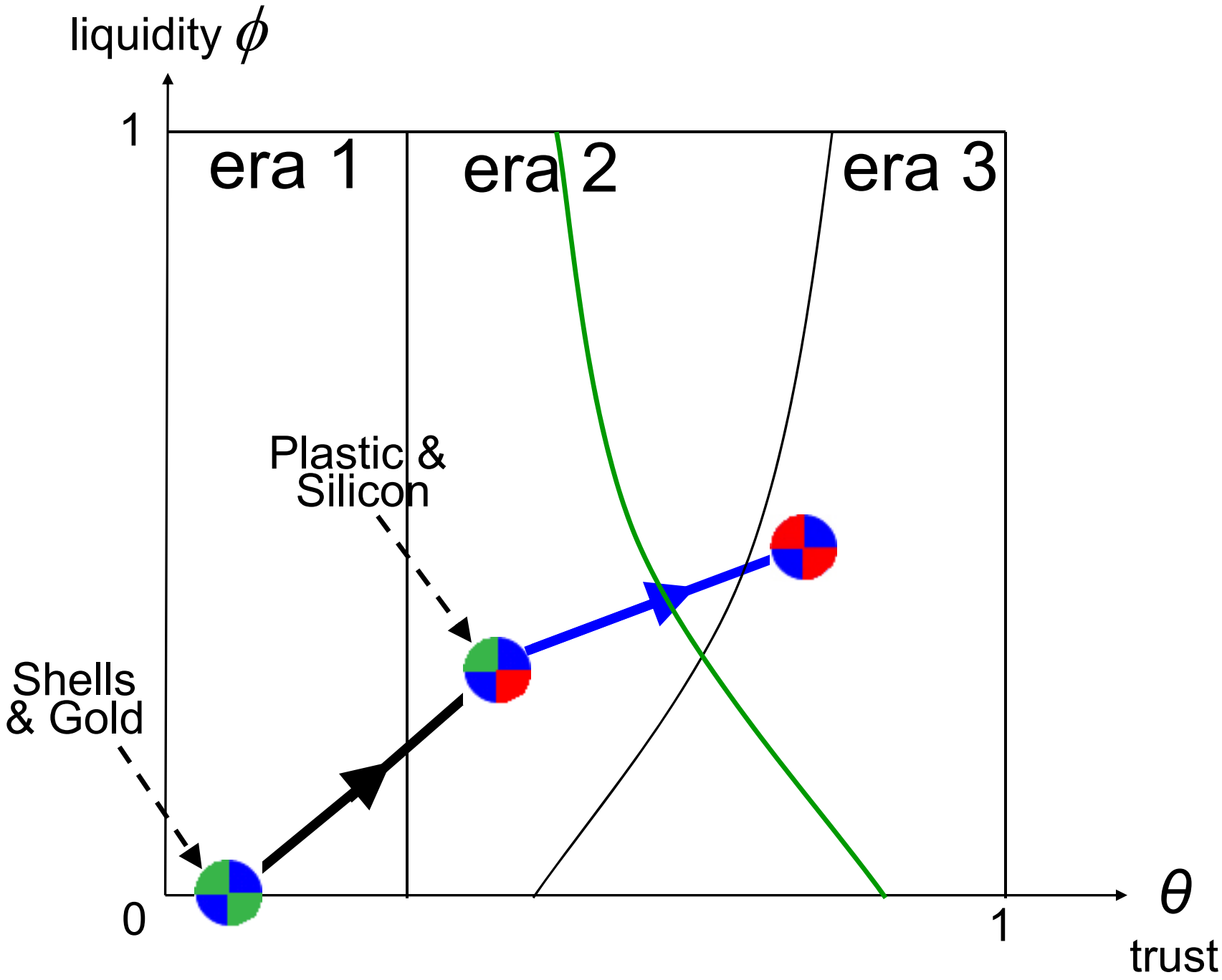
RED FUTURE?
Plastic &
Silicon
Shells
& Gold
history
0
1
θ
trust

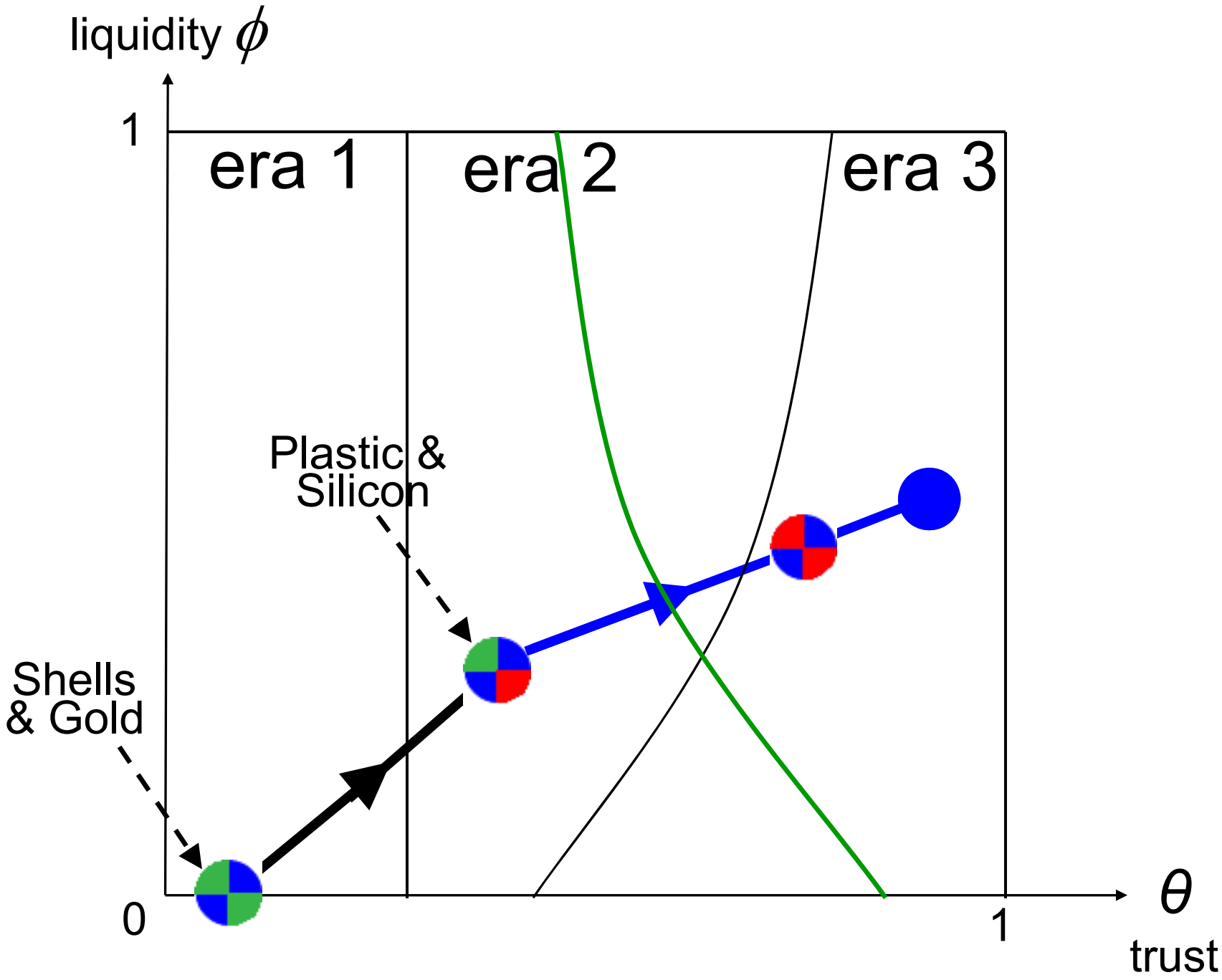

liquidity ϕ
1
era 1
era 2
era 3
no outside money
Plastic & Silicon
Shells & Gold
0
1
θ
trust

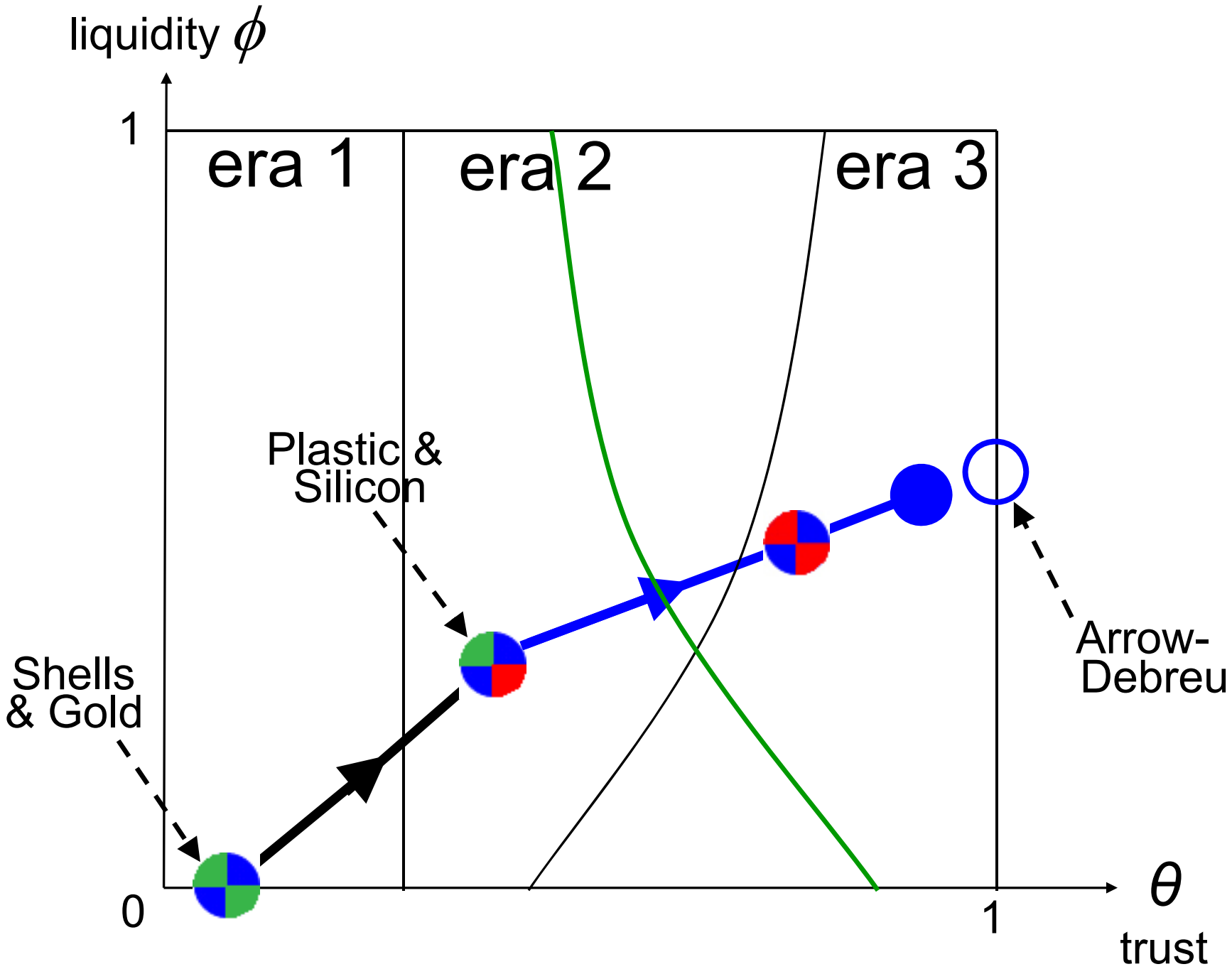

liquidity ϕ
1
era 1
era 2
era 3
no outside money
Plastic & Silicon
Shells & Gold
0
1
θ
trust

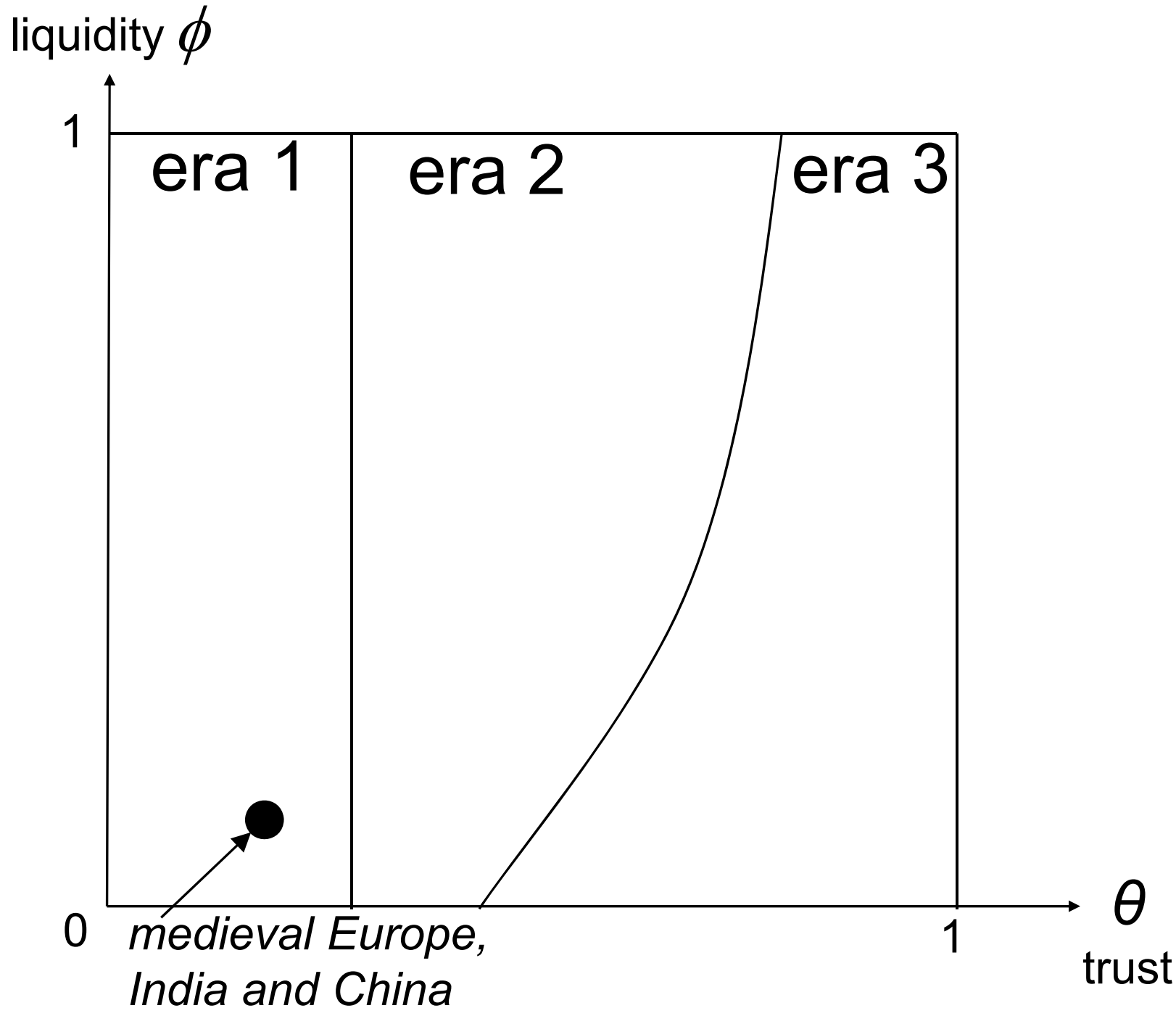

liquidity ϕ
1
0
complete
securitisation
era 1
era 2
era 3
no outside
money
Plastic &
Silicon
Shells
& Gold
1
θ
trust

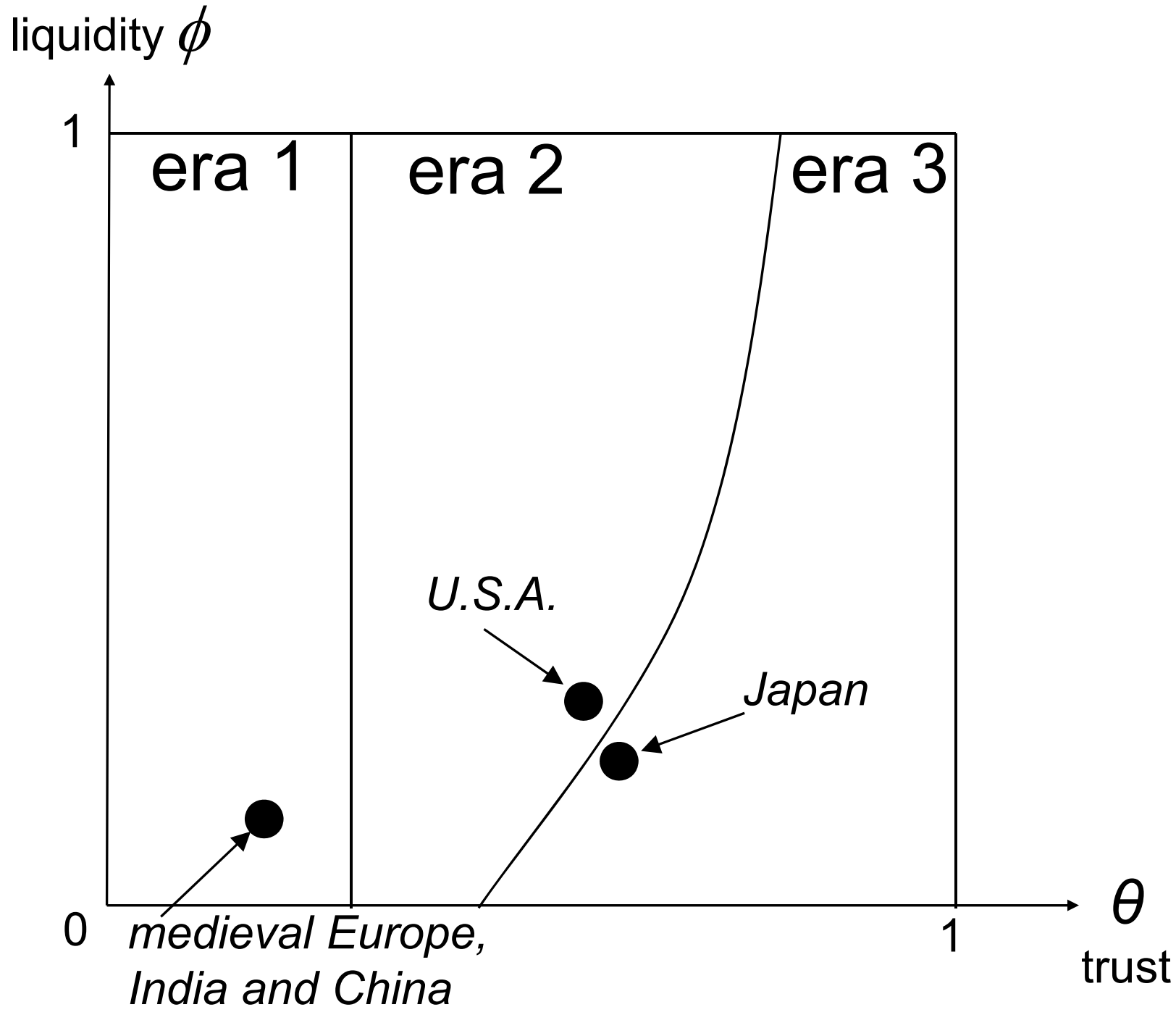

liquidity ϕ
1
era 1
era 2
era 3
Plastic &
Silicon
BLUE FUTURE ?
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
Plastic &
Silicon
Shells
& Gold
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
Plastic &
Silicon
Shells
& Gold
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
Plastic &
Silicon
Shells
& Gold
Arrow-
Debreu
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
0
medieval Europe, India and China
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
U.S.A.
Japan
0
medieval Europe,
India and China
1
θ
trust

THE MODEL

THE MODEL

discrete time t = 1, 2, 3, …

one homogenous good, corn, storable
(one for one)

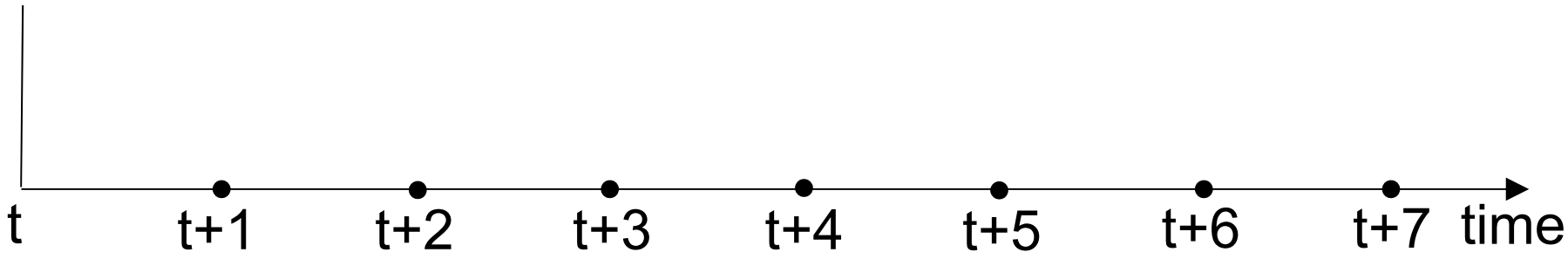
no uncertainty

infinitely lived agents choose consumption path $\{c_t, c_{t+1}, c_{t+2}, \ldots\}$ to maximise

$$\sum_{s=0}^{\infty} \beta^s \log c_{t+s} \qquad 0<\beta<1$$

each agent undertakes a sequence of projects

every 3 days, an agent starts a project that completes 2 days later:



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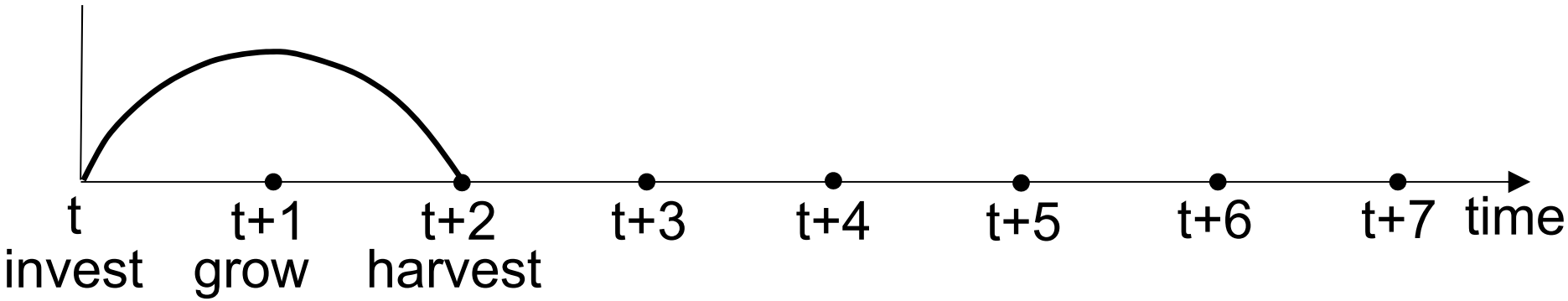

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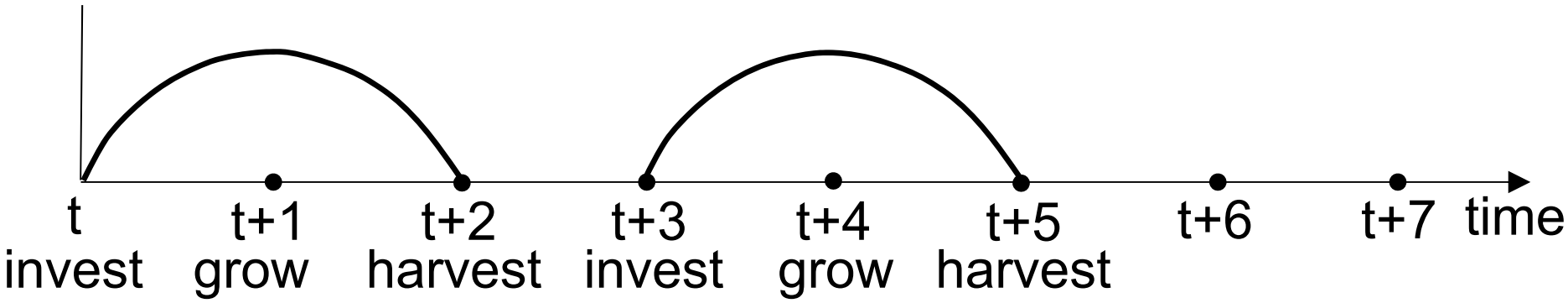

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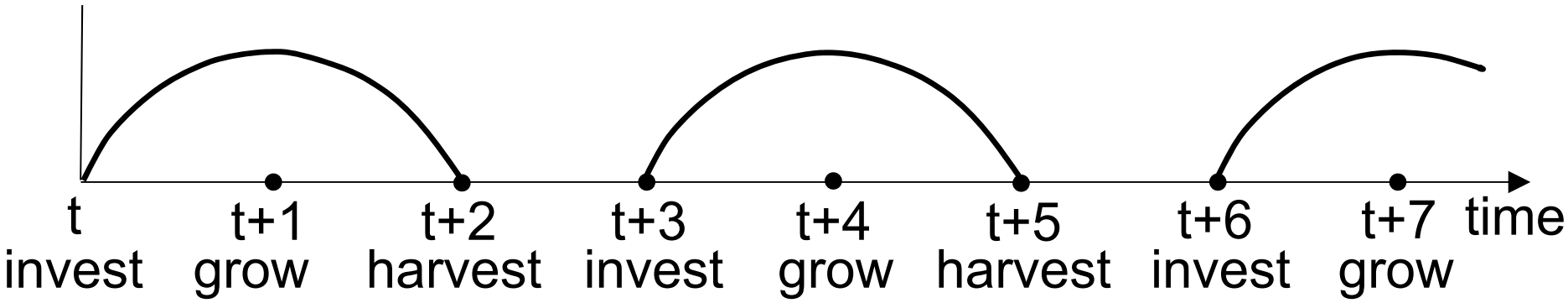

to produce y corn on day t+2 requires input G(y) corn on day t:

where $G(y) \propto y^{1/(1-\lambda)}$ $0<\lambda<1$

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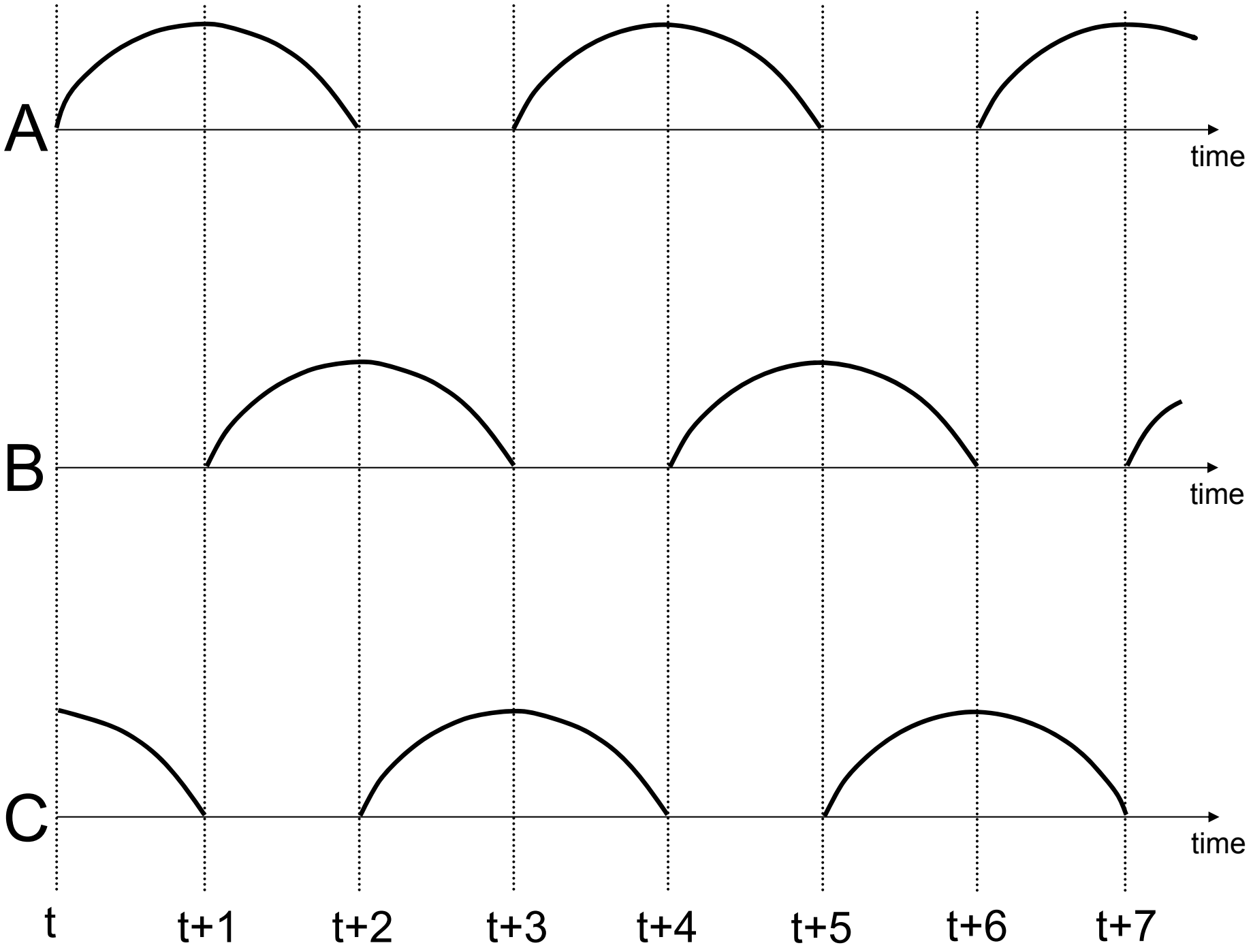
where $G(y) \propto y^{1/(1-\lambda)}$ $0<\lambda<1$

in a symmetric allocation, population is equally divided into 3 groups:

(normalise aggregate population = 3)


A
time
B
time
C
time
t
t+1
t+2
t+3
t+4
t+5
t+6
t+7

first-best (Arrow-Debreu):

efficient production: $G'(y^*) = \beta^2$

smooth consumption: $c_t \equiv \frac{1}{3}[y^* - G(y^*)]$

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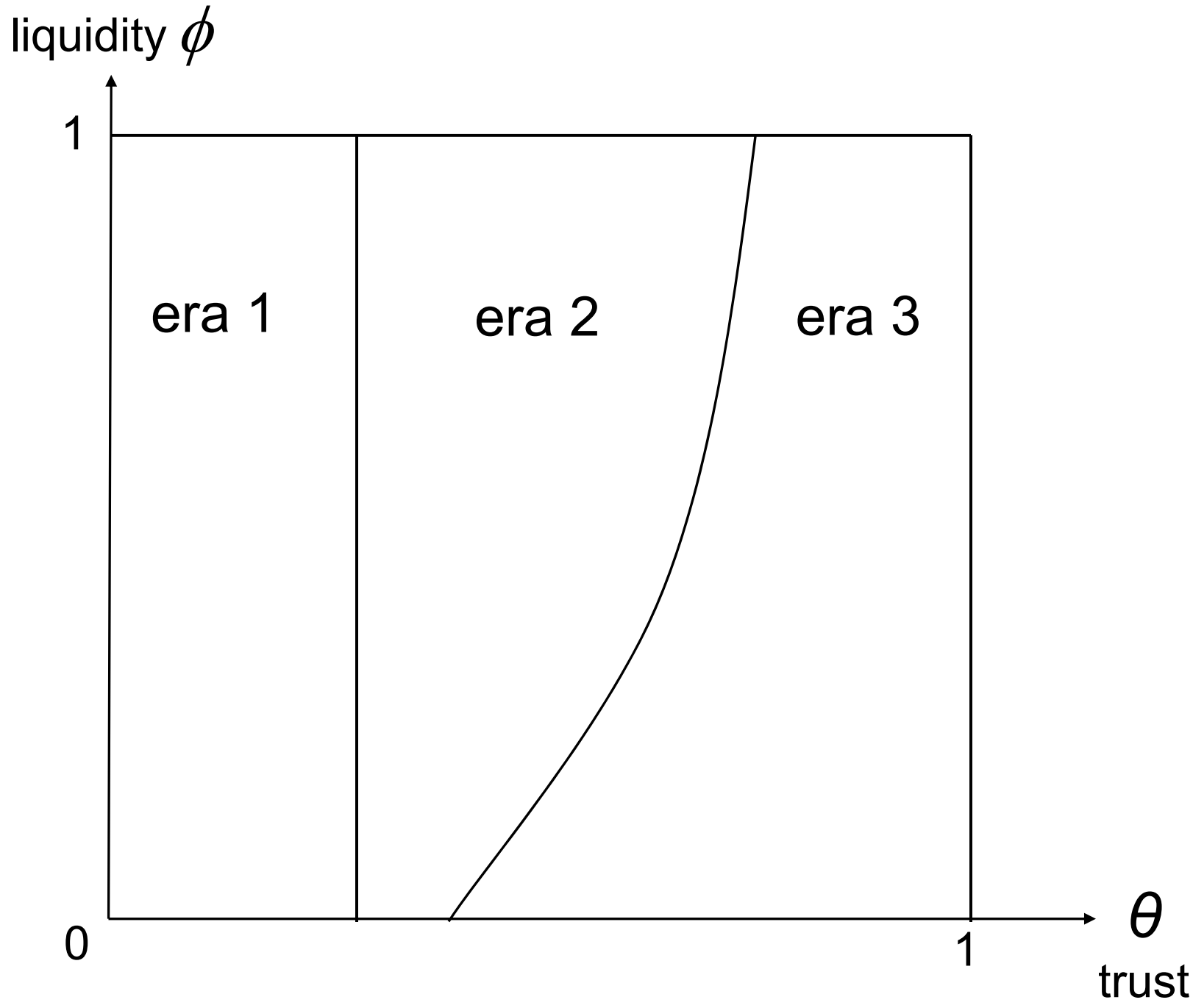
efficient production: $G'(y^*) = \beta^2$

smooth consumption: $c_t \equiv \frac{1}{3}[y^* - G(y^*)]$

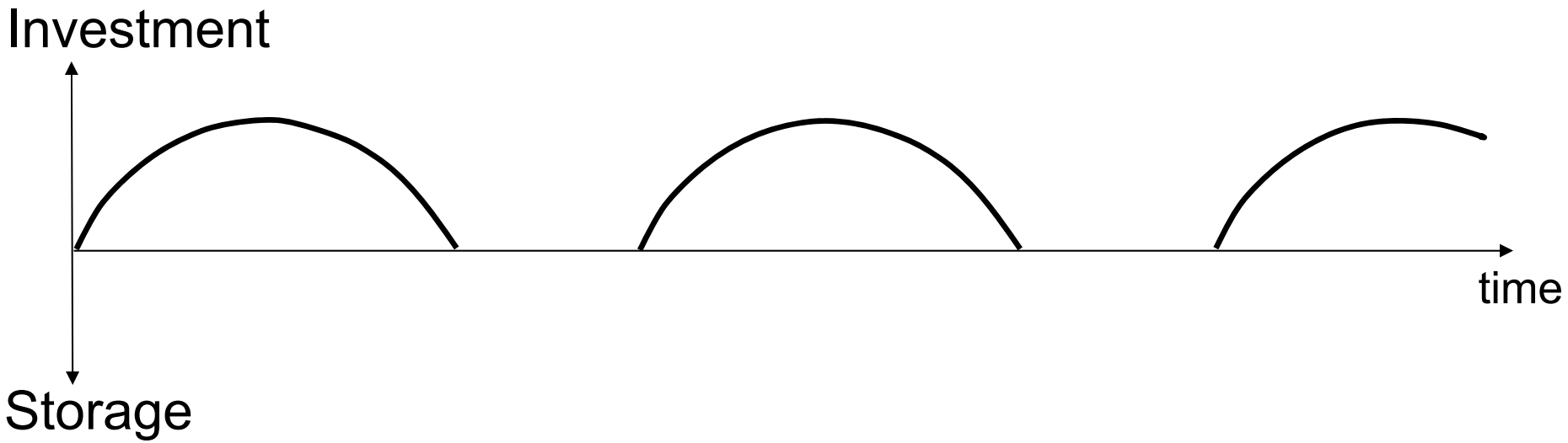
BUT, unlike in Arrow-Debreu, we assume

$$\theta < 1$$

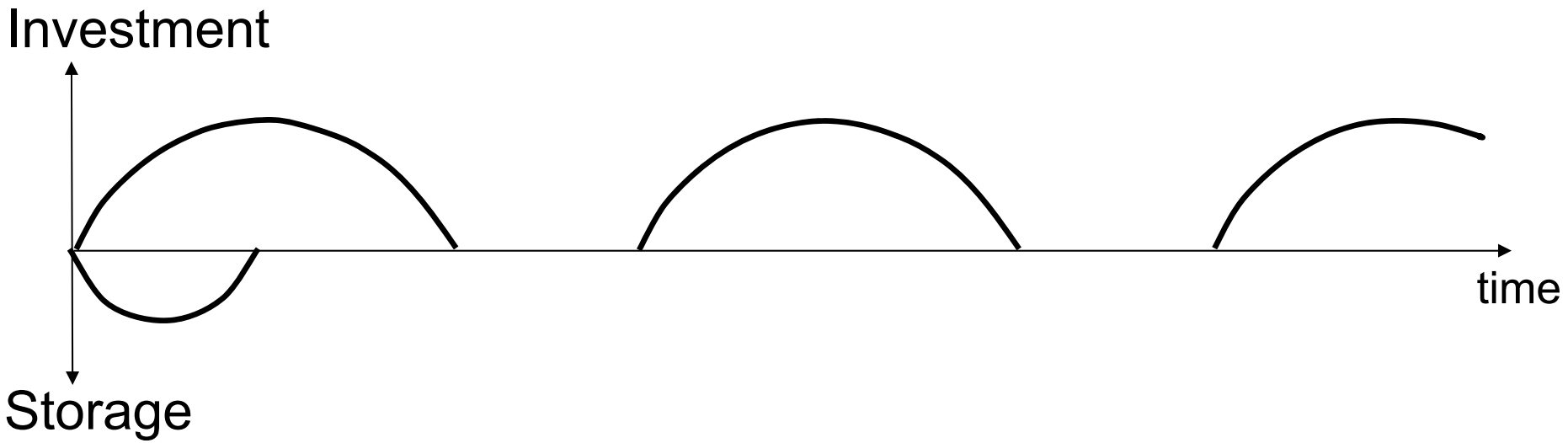
at start of a project, investing agent can credibly promise at most θy of harvest y


liquidity ϕ
1
era 1
era 2
era 3
0
1
θ
trust

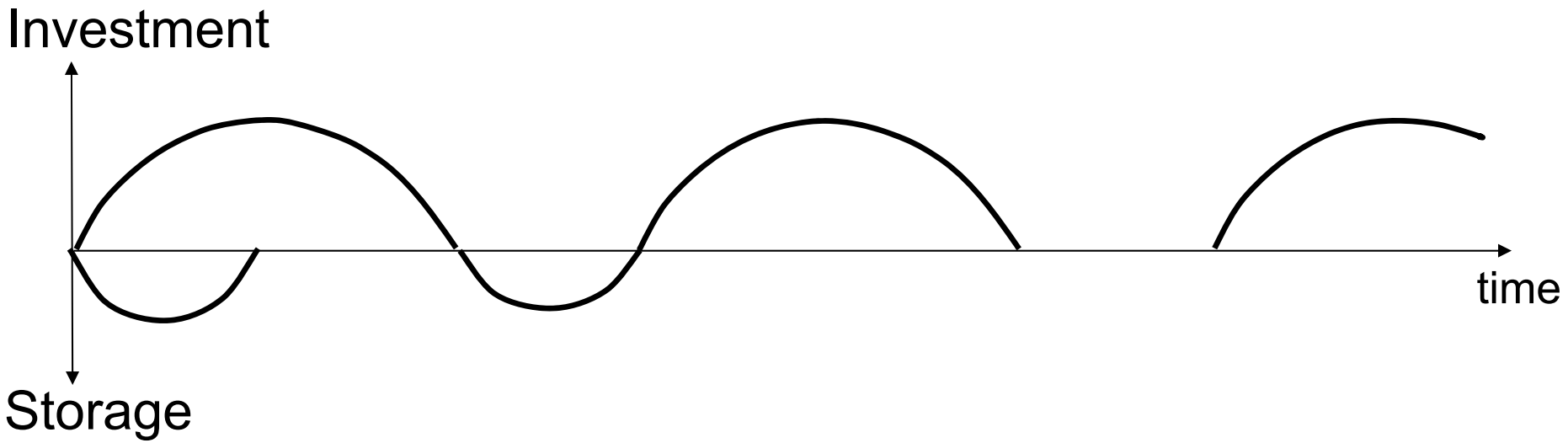
extreme case: θ = 0 (autarky; Robinson Crusoe)



extreme case: θ = 0 (autarky; Robinson Crusoe)



extreme case: θ = 0 (autarky; Robinson Crusoe)



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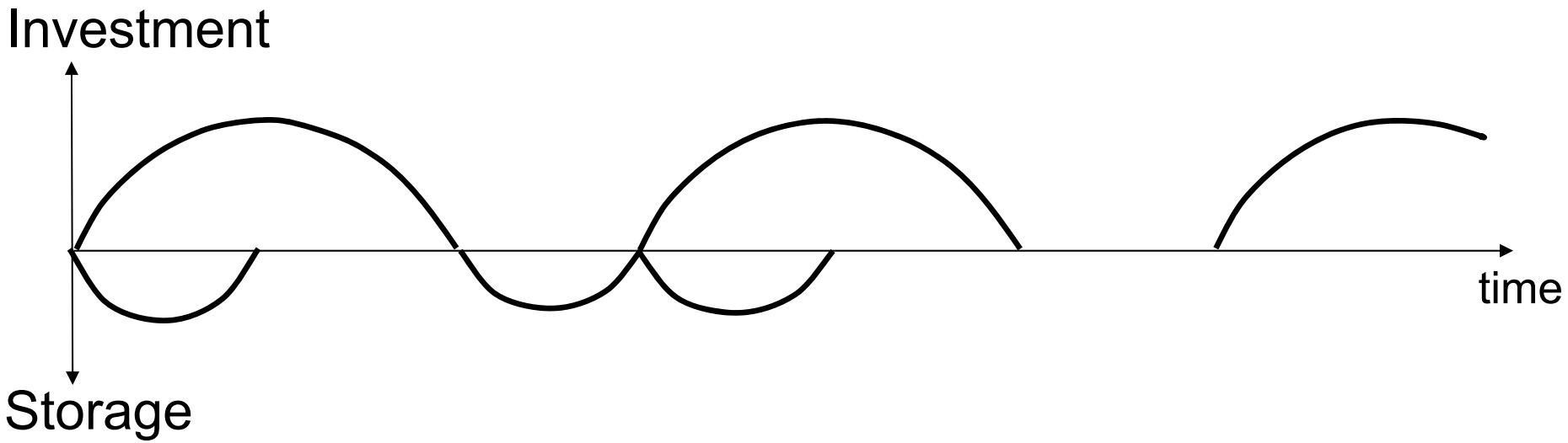
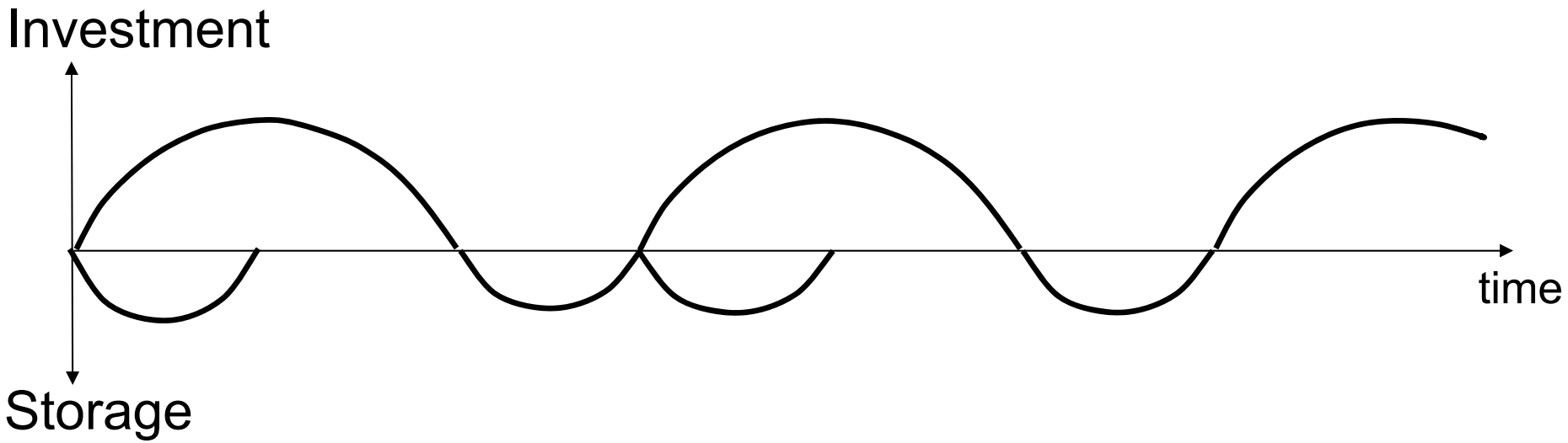


extreme case: θ = 0 (autarky; Robinson Crusoe)



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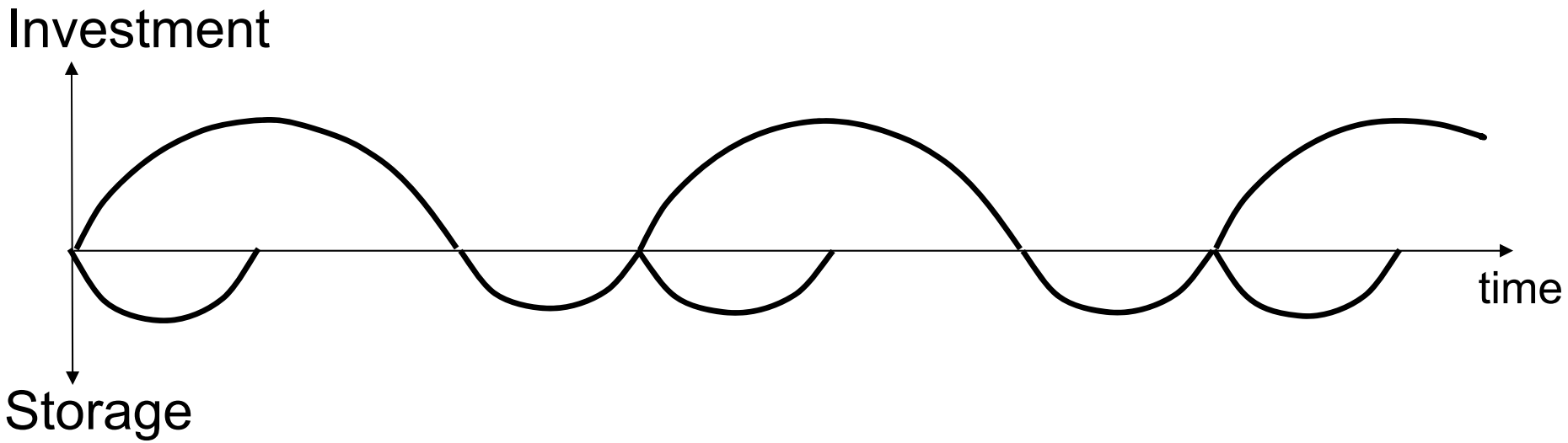

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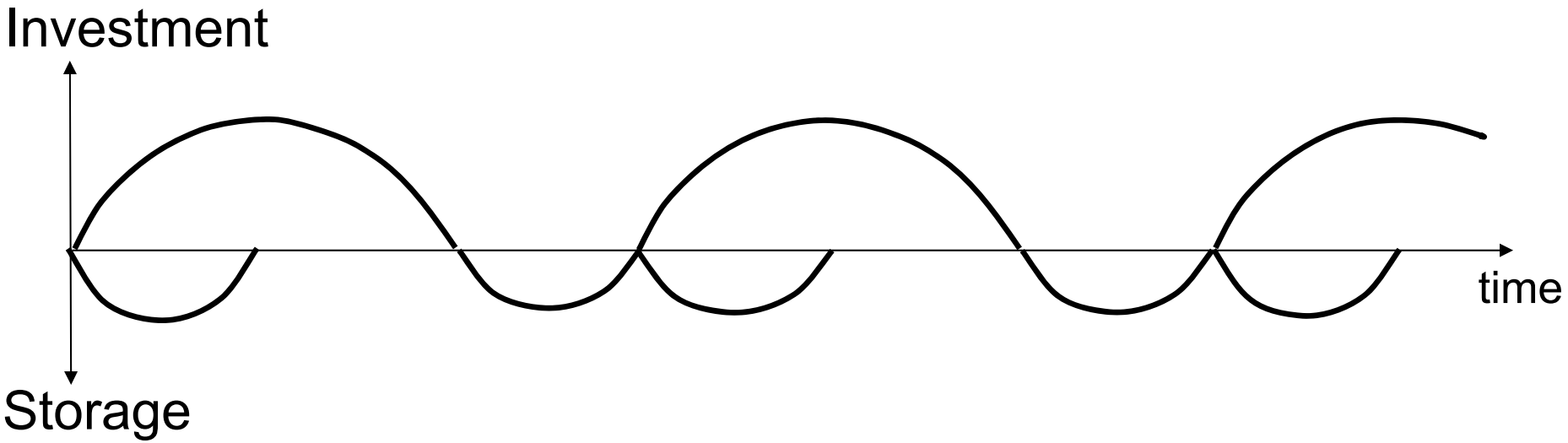
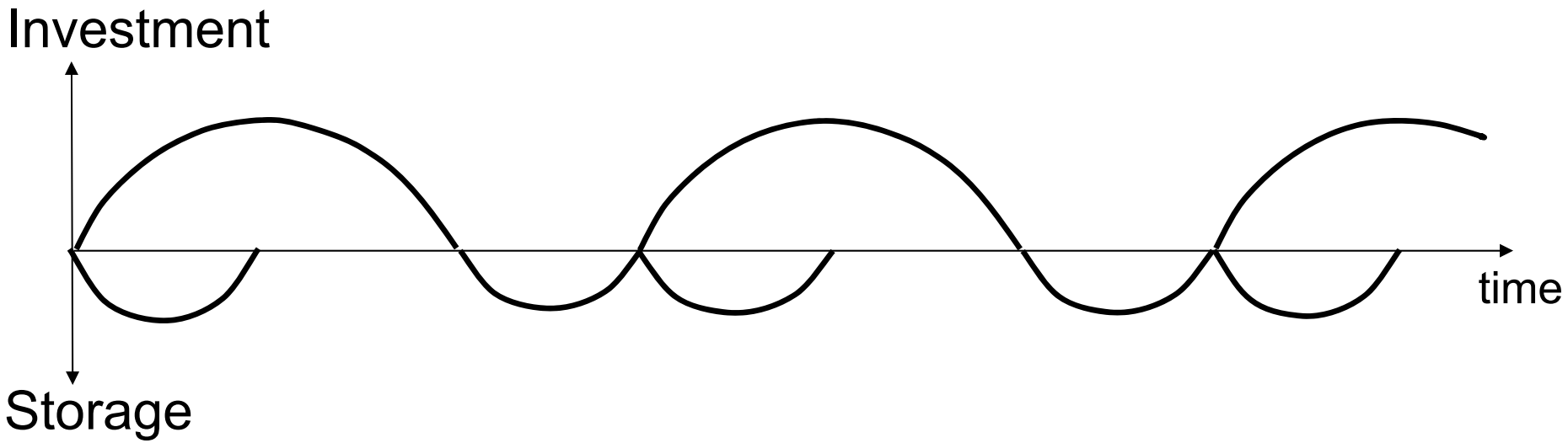


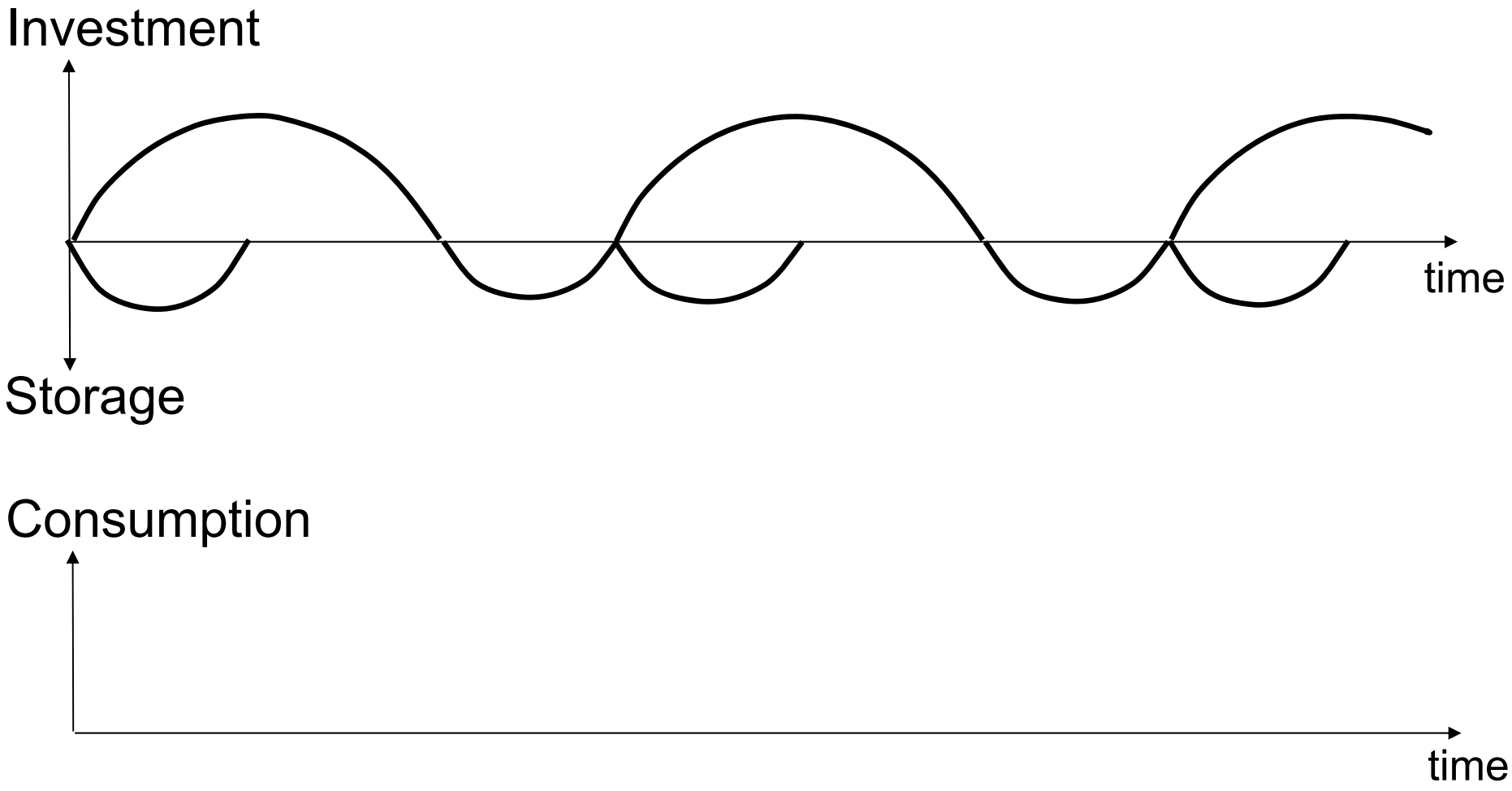
$G'(y) = \beta^3$ => y below y*
under-investment

extreme case: $\theta = 0$ (autarky; Robinson Crusoe)



not only is there under-investment,
but there is also jagged consumption:

extreme case: θ = 0 (autarky; Robinson Crusoe)



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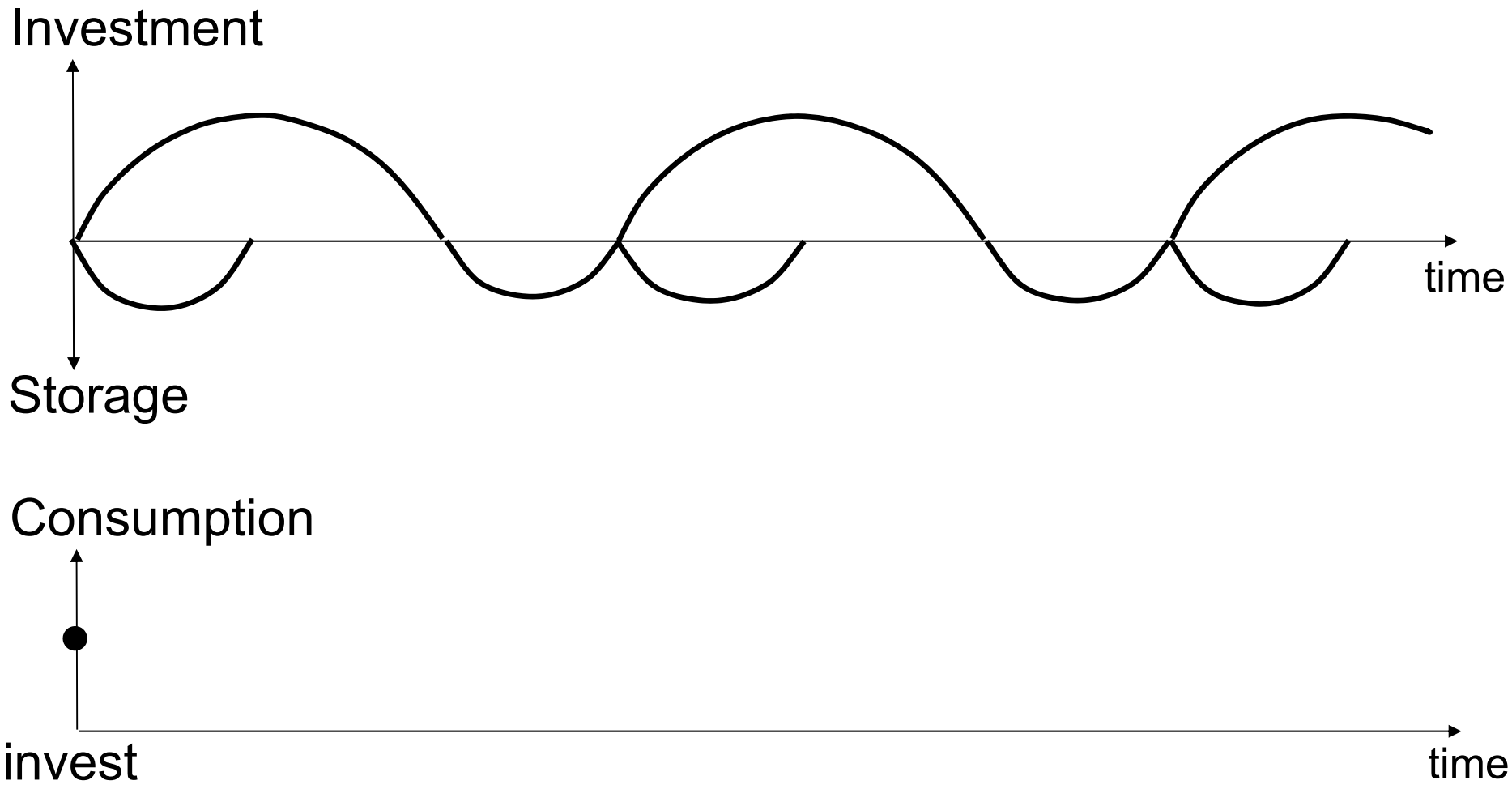

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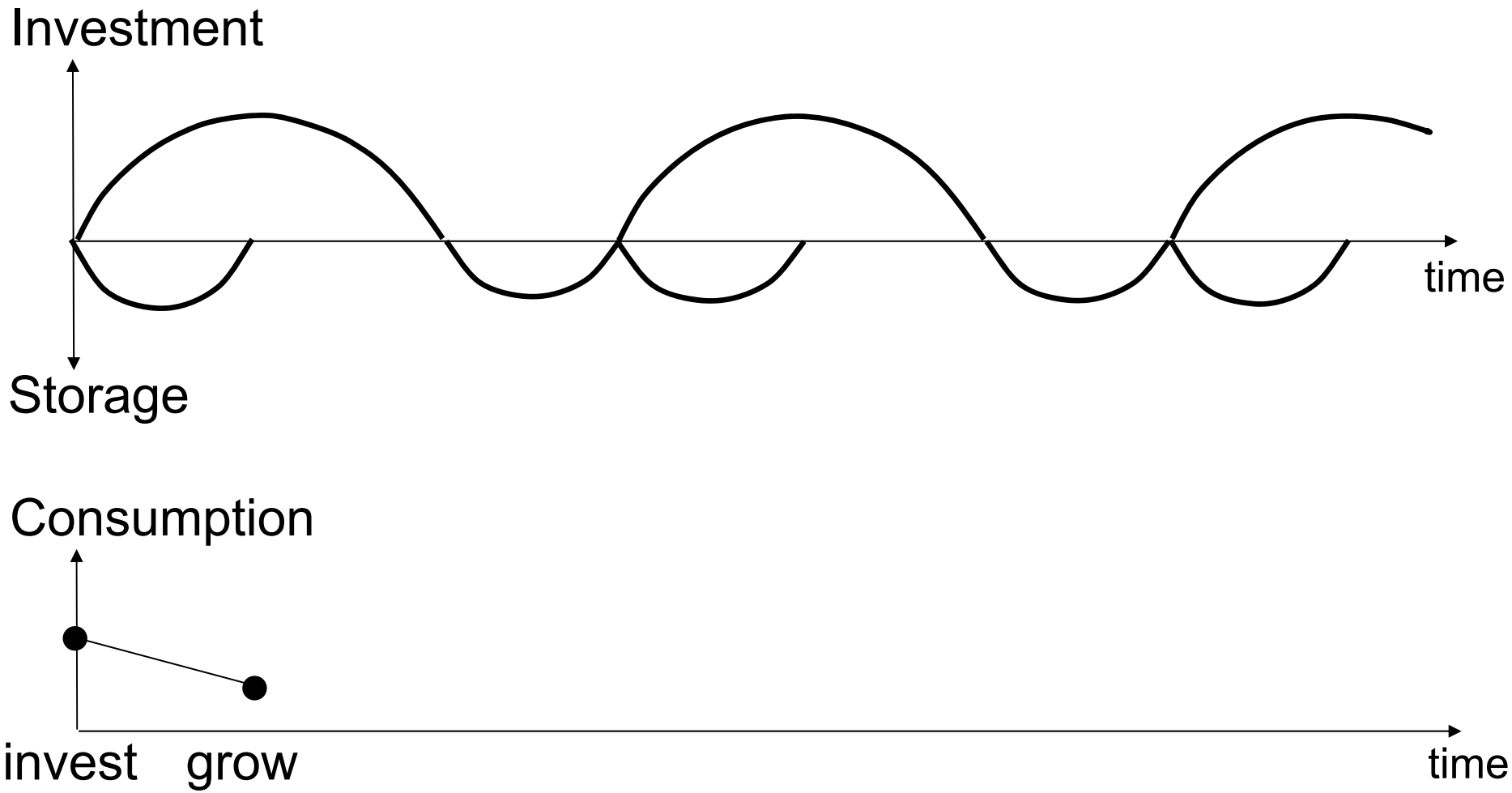

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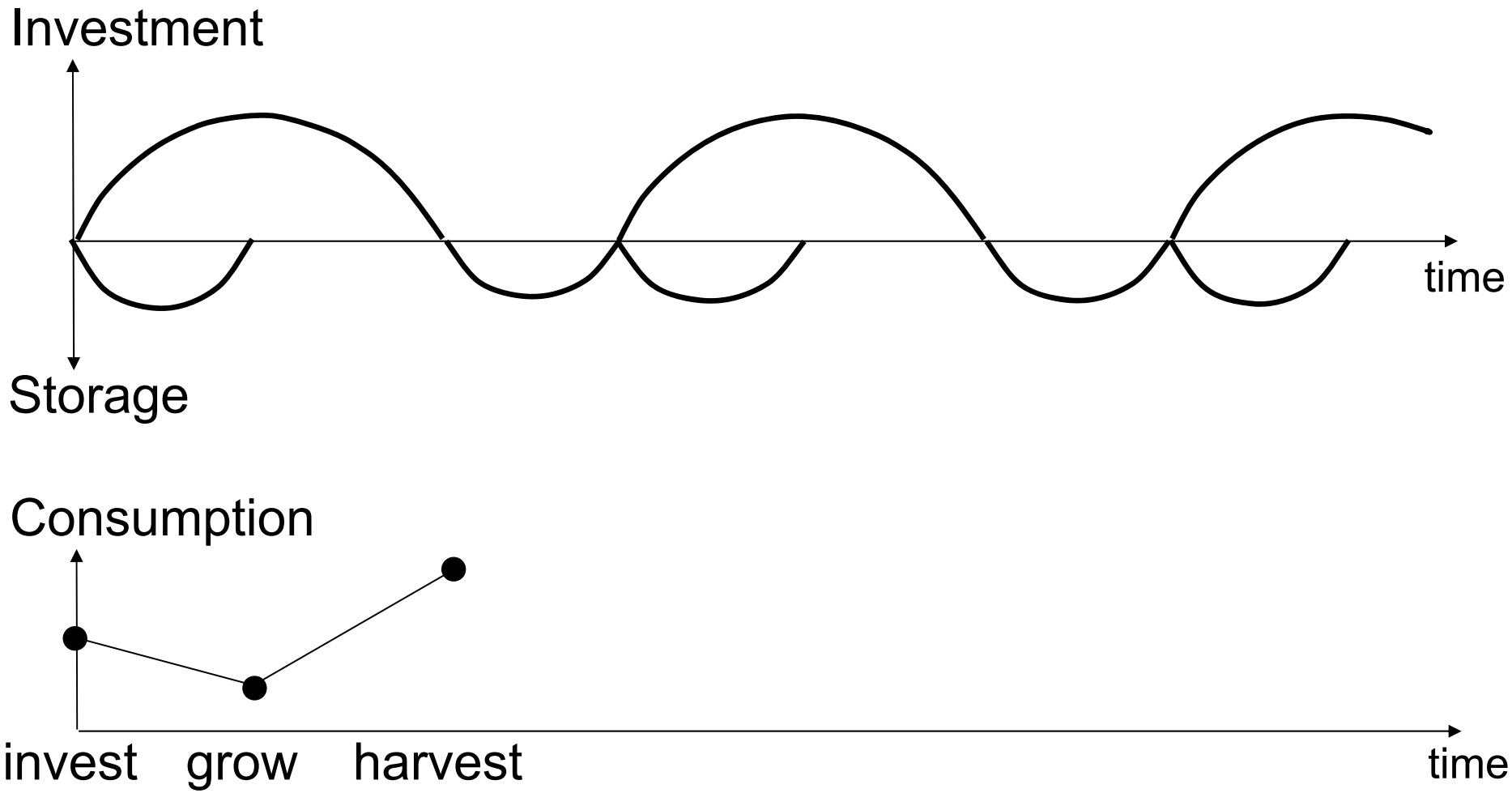

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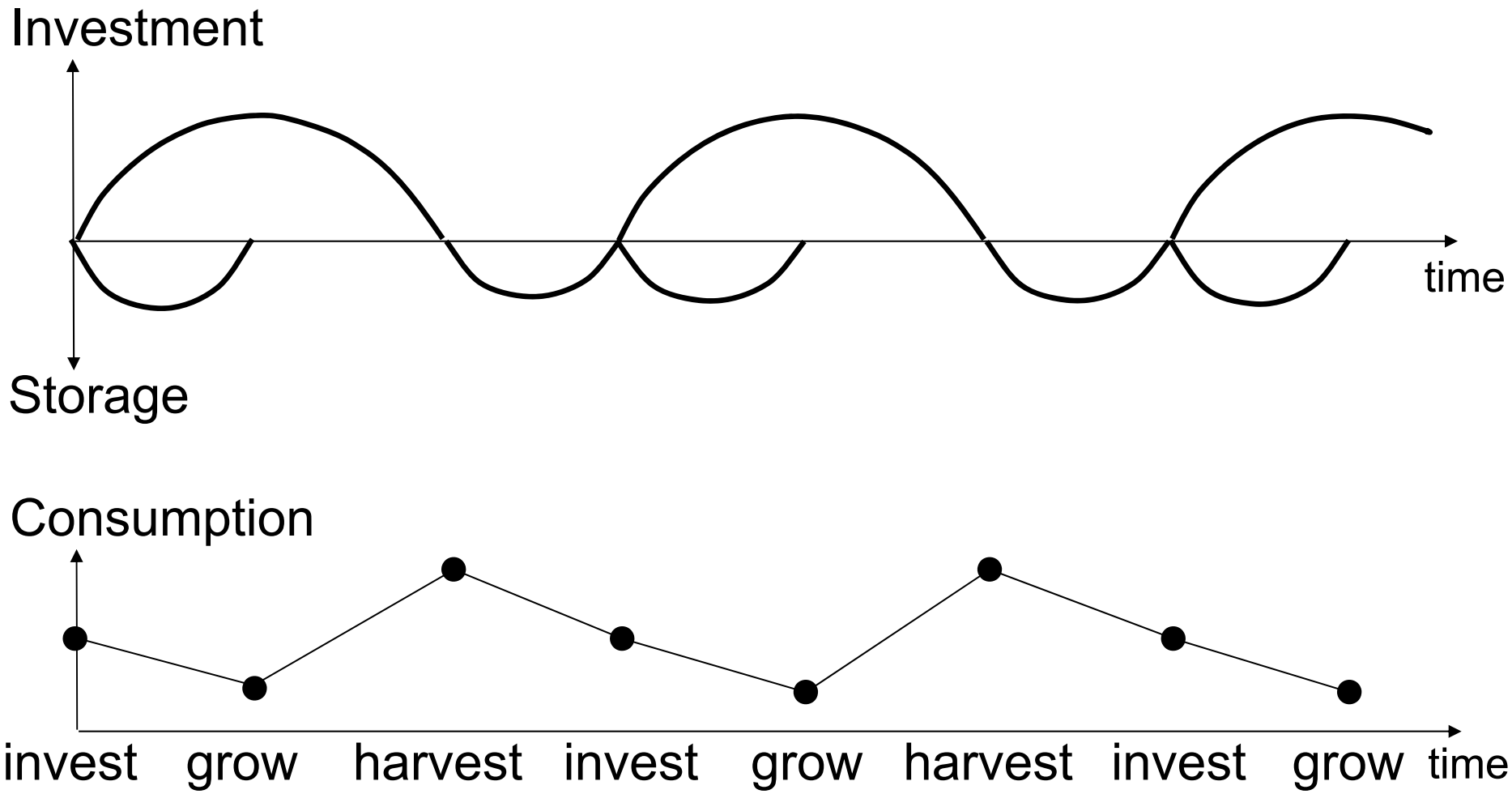
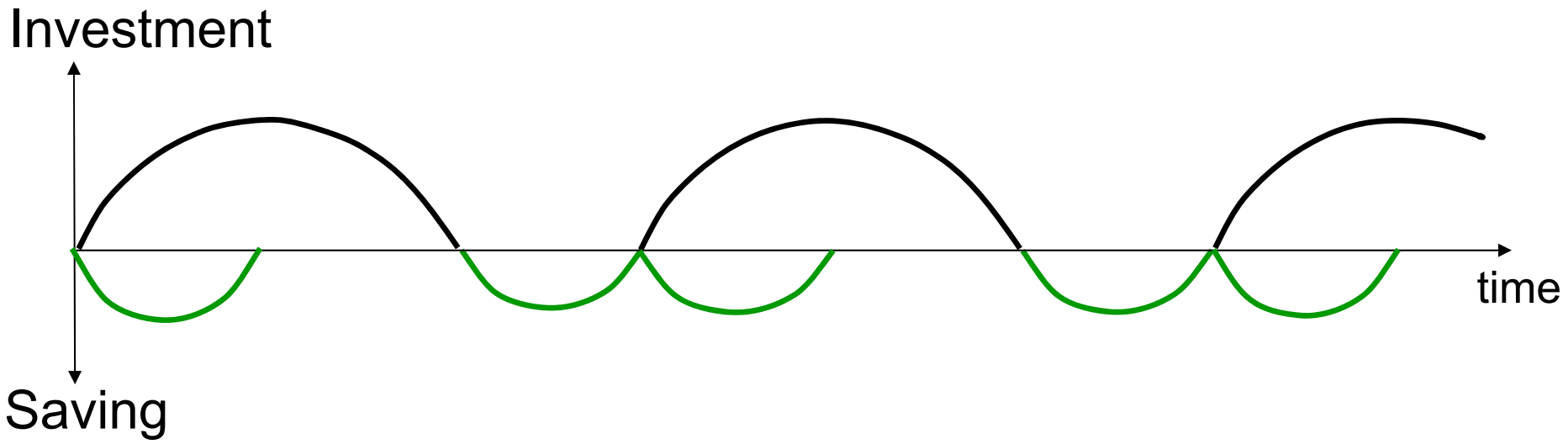


extreme case: $\theta = 0$ (autarky; Robinson Crusoe)



introduce outside money (green paper): same steady-state allocations as in autarky except that no corn need be tied up in storage (Samuelson, 1958)

less extreme: $\theta > 0$

i.e. investing agent *can* issue private paper

but adverse selection causes the
secondary market to break down …

assume project comprises a large number of parts, some of which are lemons

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no-one can distinguish lemons on day of investment, day t

insiders privately learn which parts are lemons by day t+1

outsiders remain uninformed until day t+2

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no-one can distinguish lemons on day of investment, day t

insiders privately learn which parts are lemons by day t+1

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but there is a remedy …

at start of project (day t), investing agent can bundle parts together so that lemons cannot be separated out later (day t+1)

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bundling ≡ financial intermediation/banking

converts illiquid paper (blue paper) that *cannot* be resold at t+1

into liquid paper (red paper) that *can* be resold at t+1

cost of bundling a portion z ($\leq$ y) of output:

$$\frac{1-\phi}{\phi}\, G(z) \qquad\qquad 0<\phi<1$$

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costs are deadweight (no extra output)

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$$\frac{1-\phi}{\phi}\, G(z) \qquad 0<\phi<1$$

costs are deadweight (no extra output)

($\Rightarrow$ in first-best, there is

no bundling, no banking
no inside money, no red paper)

q = issue price of blue paper

(price in terms of day t corn of a credible claim to day t+2 corn, that *cannot* be resold on day t+1)

p^2 = issue price of red paper

(price in terms of day t corn of a credible claim to day t+2 corn, that *can* be resold on day t+1, at price p)

basic inequalities:

$$1 \geq p^2 \geq q \geq \beta^2$$

result!

if $p < 1$ then green paper not used

in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$(\frac{1}{p} - 1)$	$\uparrow$	$(\frac{1}{\sqrt{q}} - 1)$		$(\frac{1}{\beta} - 1)$

liquidity premium

in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$(\frac{1}{p} - 1)$		$(\frac{1}{\sqrt{q}} - 1)$		$(\frac{1}{\beta} - 1)$

liquidity premium

$$\frac{1}{\sqrt{q}} - \frac{1}{p} = \text{Keynesian interest rate r}$$

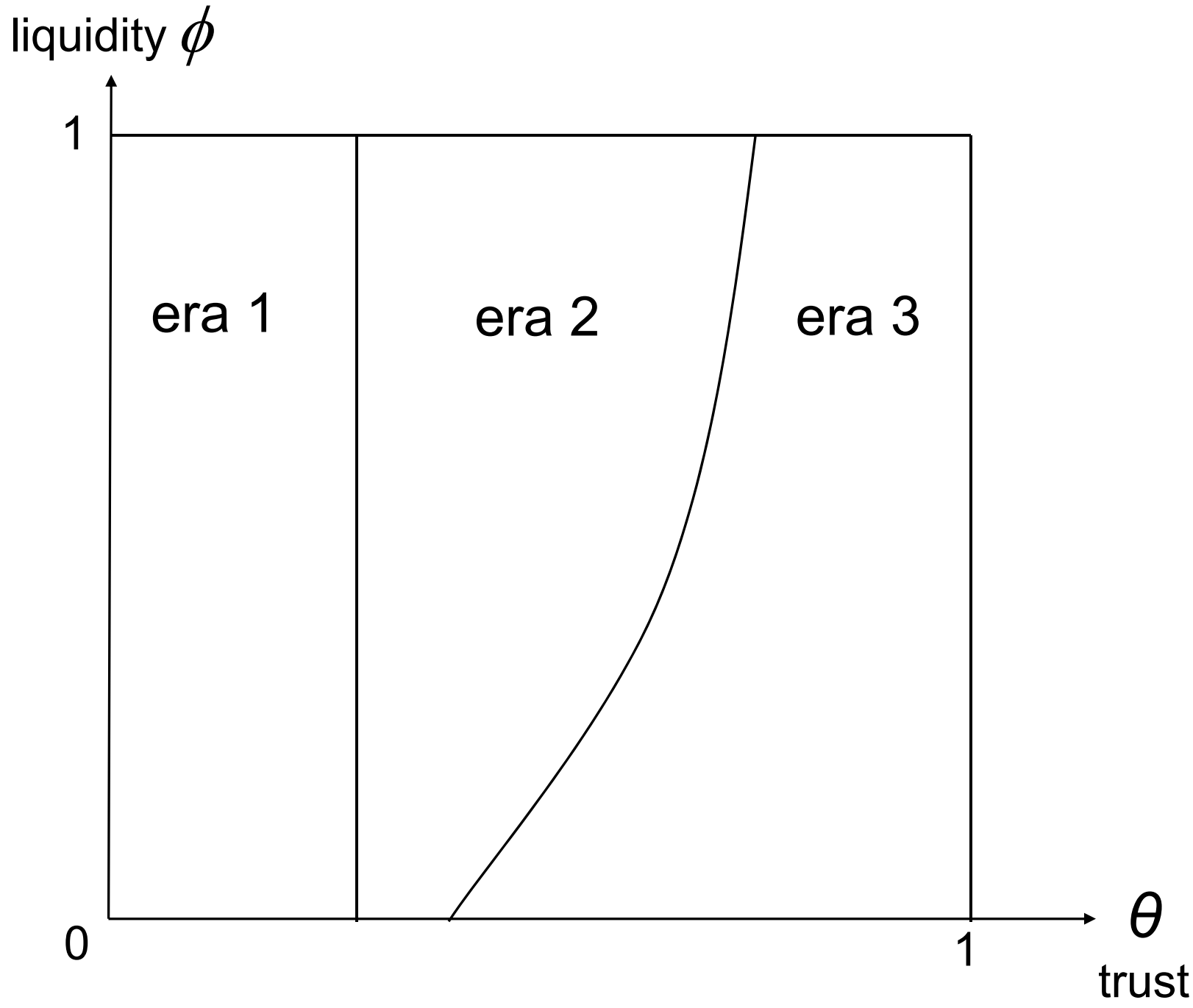
in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$(\frac{1}{p} - 1)$		$(\frac{1}{\sqrt{q}} - 1)$		$(\frac{1}{\beta} - 1)$

liquidity premium

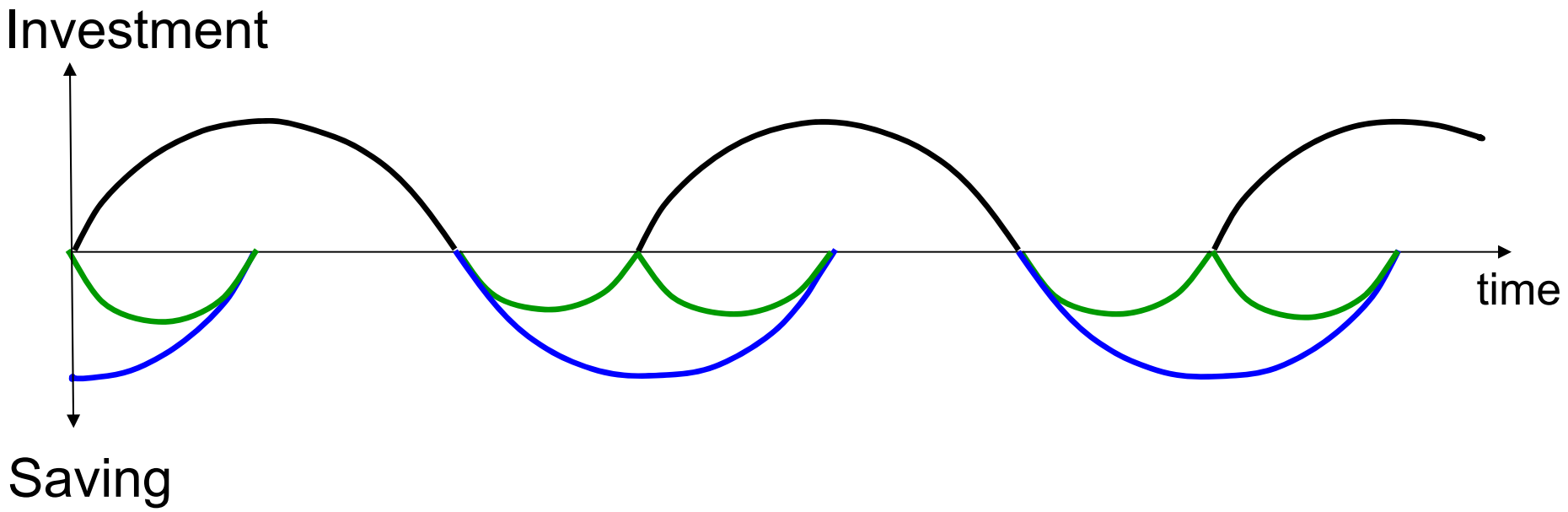
$$\frac{1}{\sqrt{q}} - \frac{1}{p} = \text{Keynesian interest rate r}$$

when green paper used (p=1), $r = \frac{1}{\sqrt{q}} - 1$


liquidity ϕ
1
era 1
era 2
era 3
0
1
θ
trust

era 1

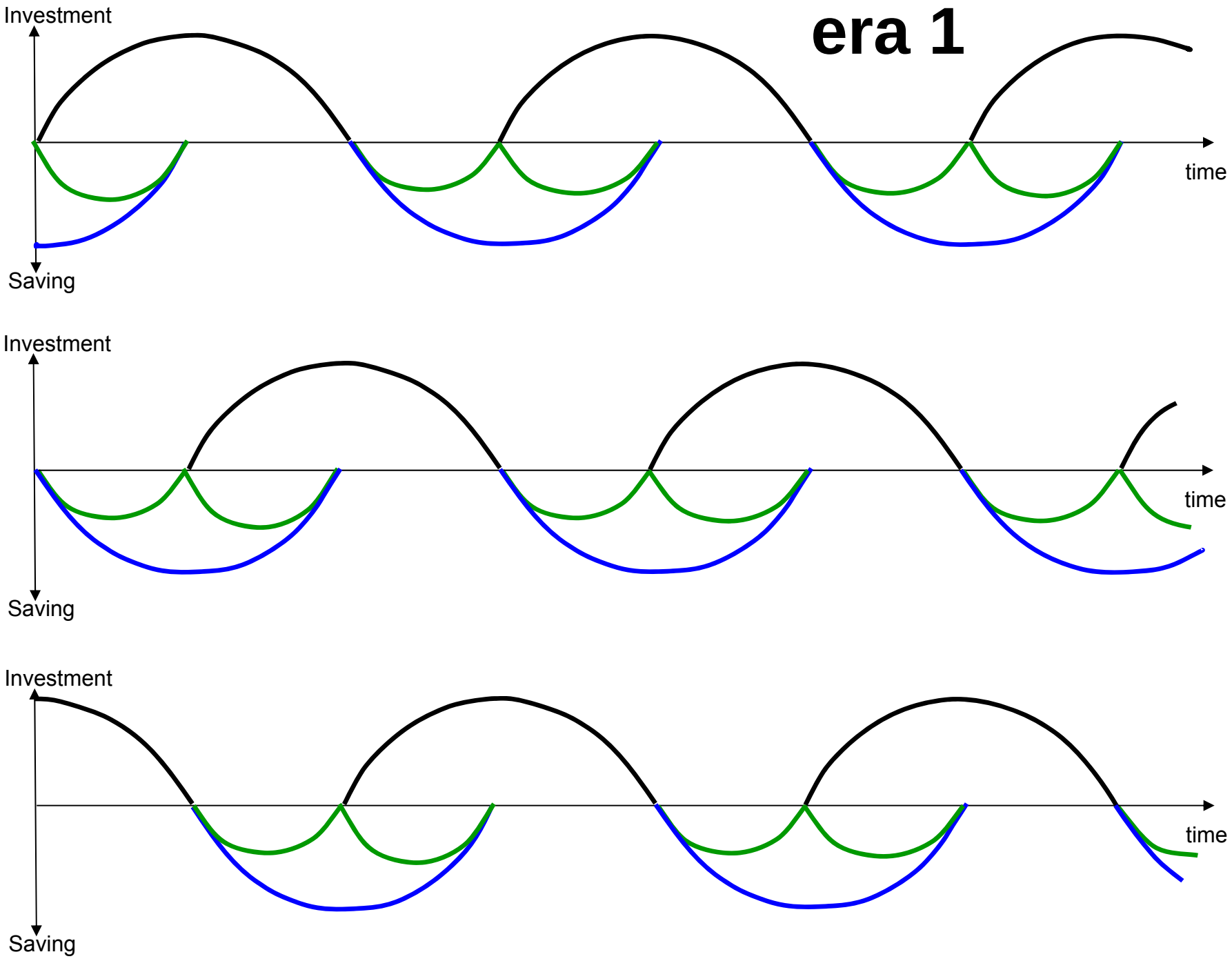
era 1



blue paper competes with green paper (held twice)

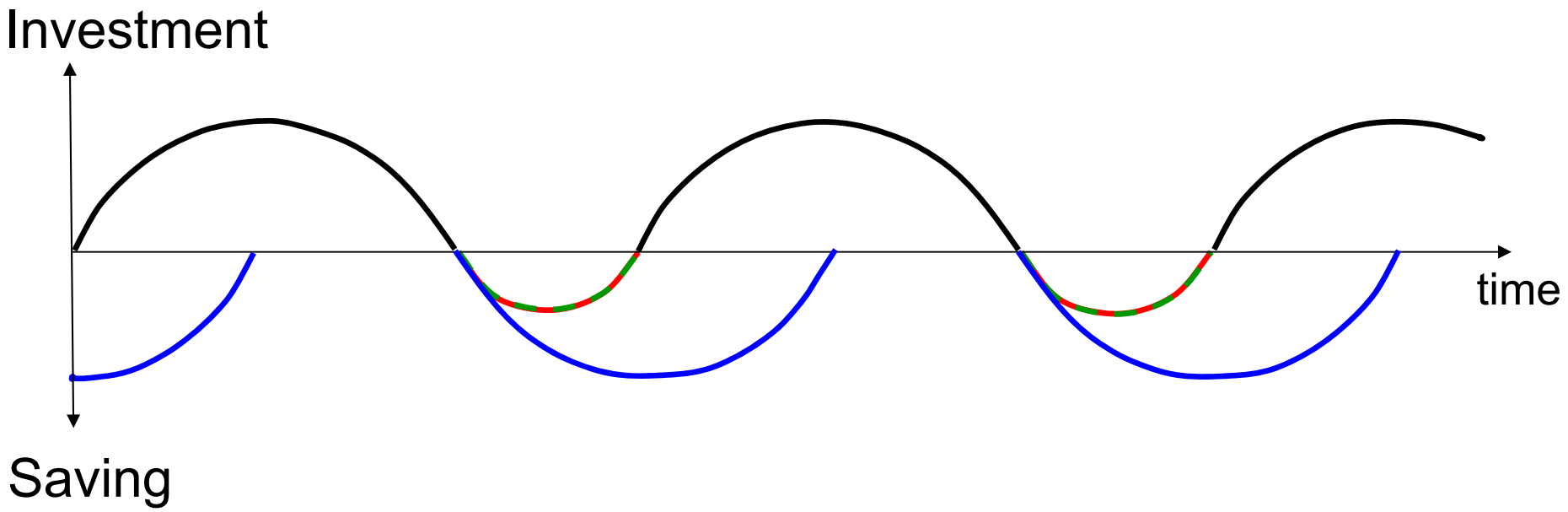
$\Rightarrow$ q = 1: no liquidity premium

$\Rightarrow$ no bundling: no red paper


era 1
Investment
time
Saving
Investment
time
Saving
Investment
time
Saving

era 2

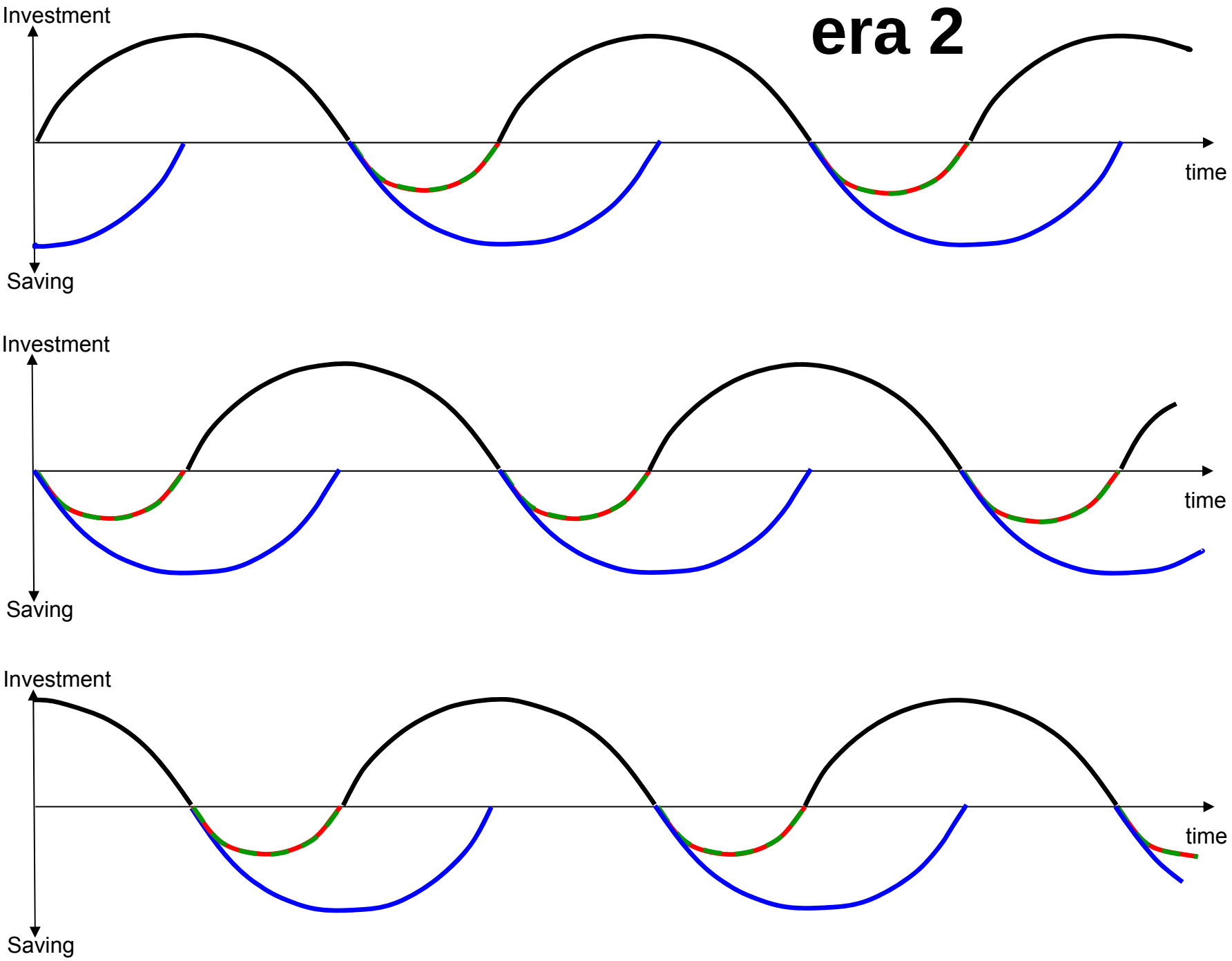
era 2



$$1 \geq p^2 > q > \beta^2$$

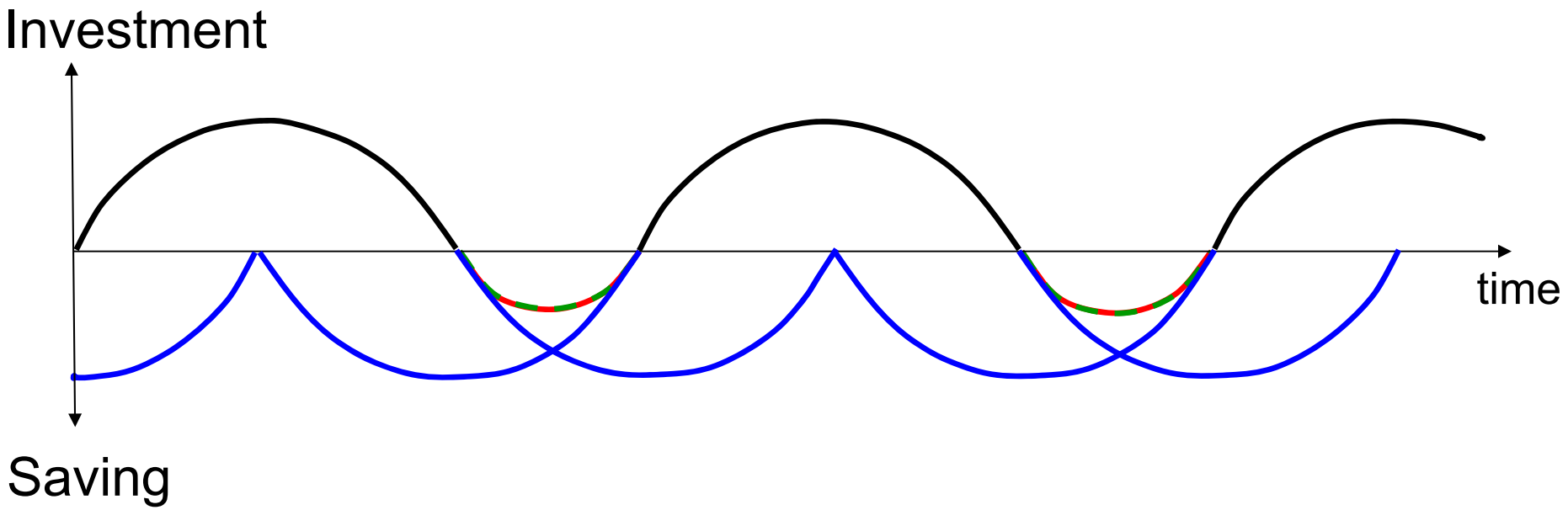
if strict, green paper
does not circulate

positive liquidity premium
$\Rightarrow$ bundling, red paper

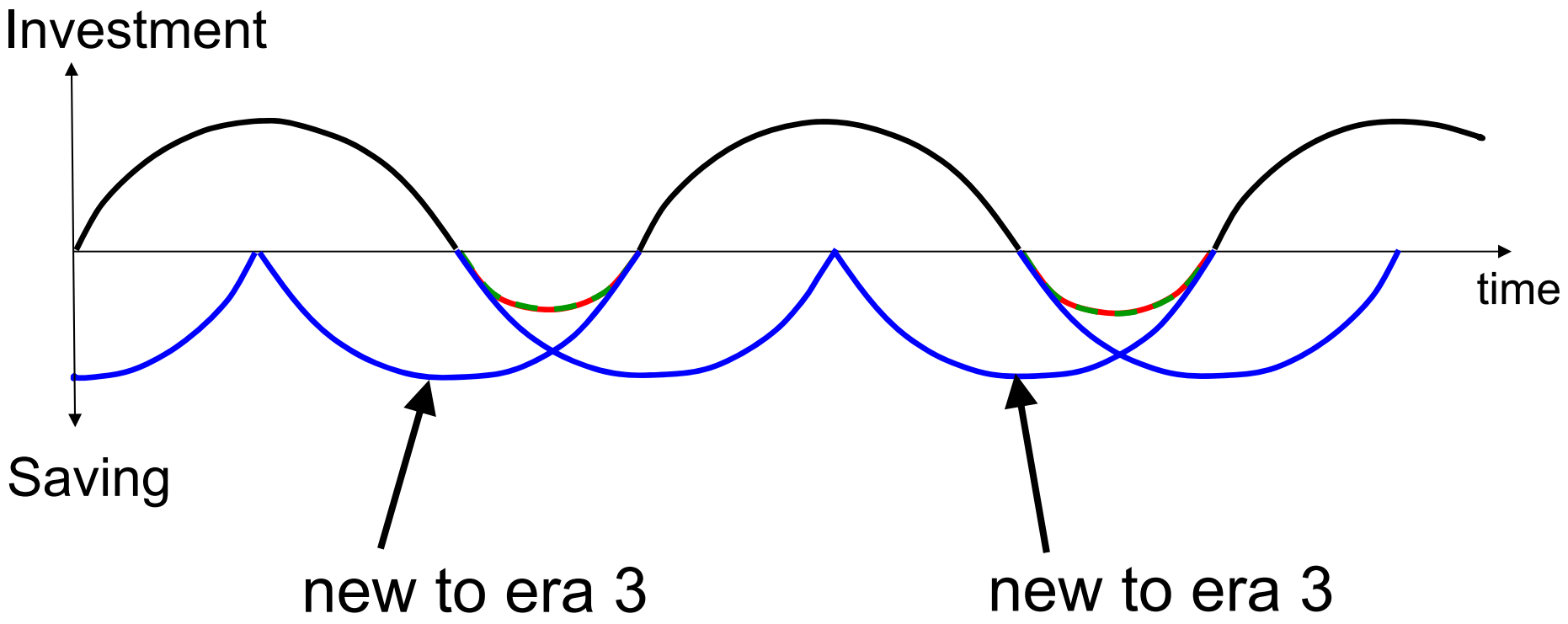

era 2
Investment
time
Saving
Investment
time
Saving
Investment
time
Saving

era 3

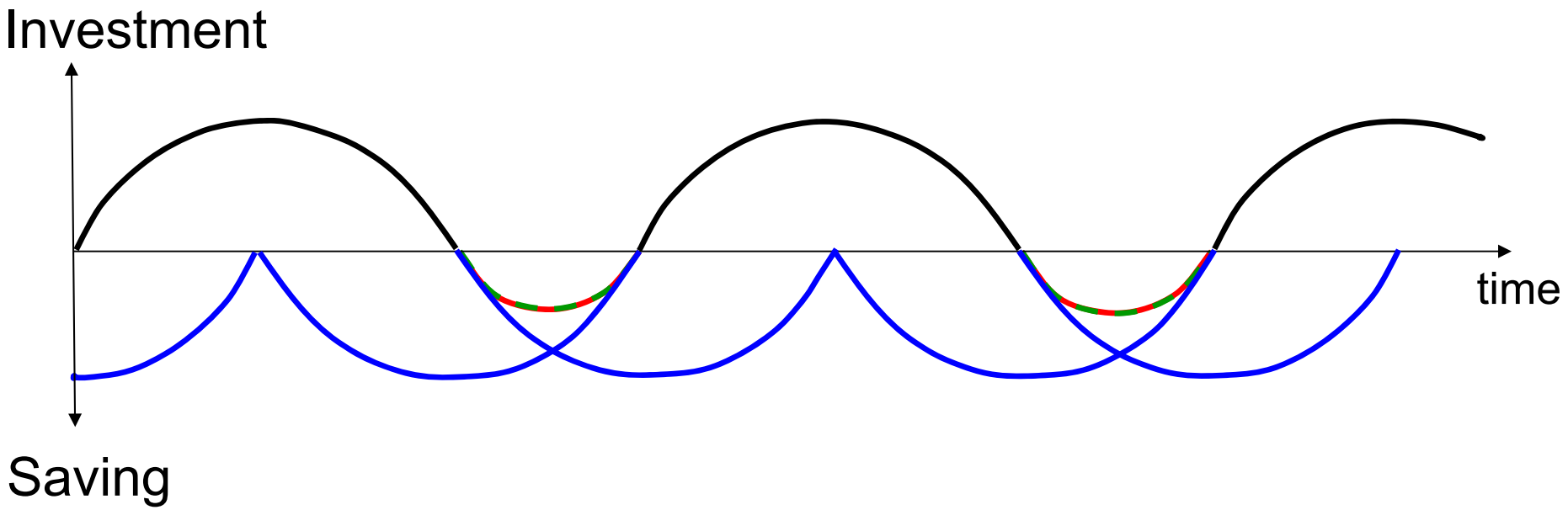
era 3



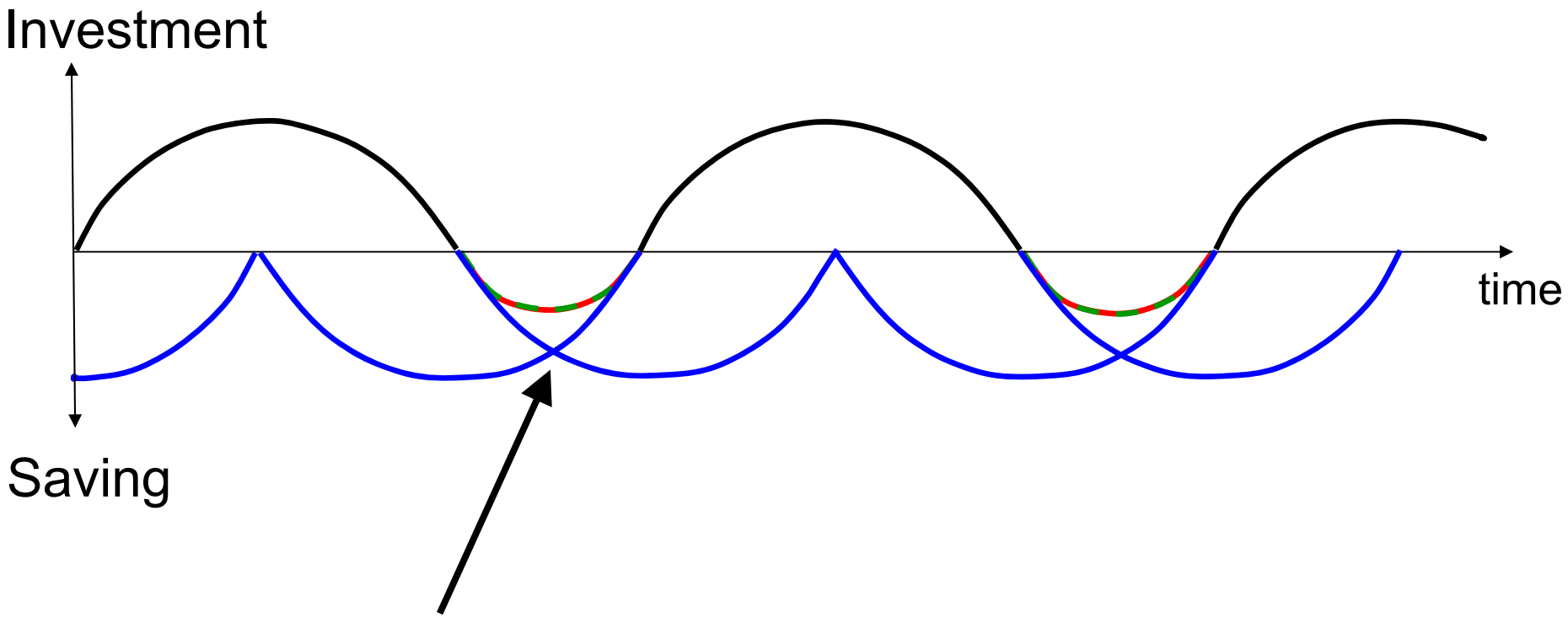
era 3



era 3

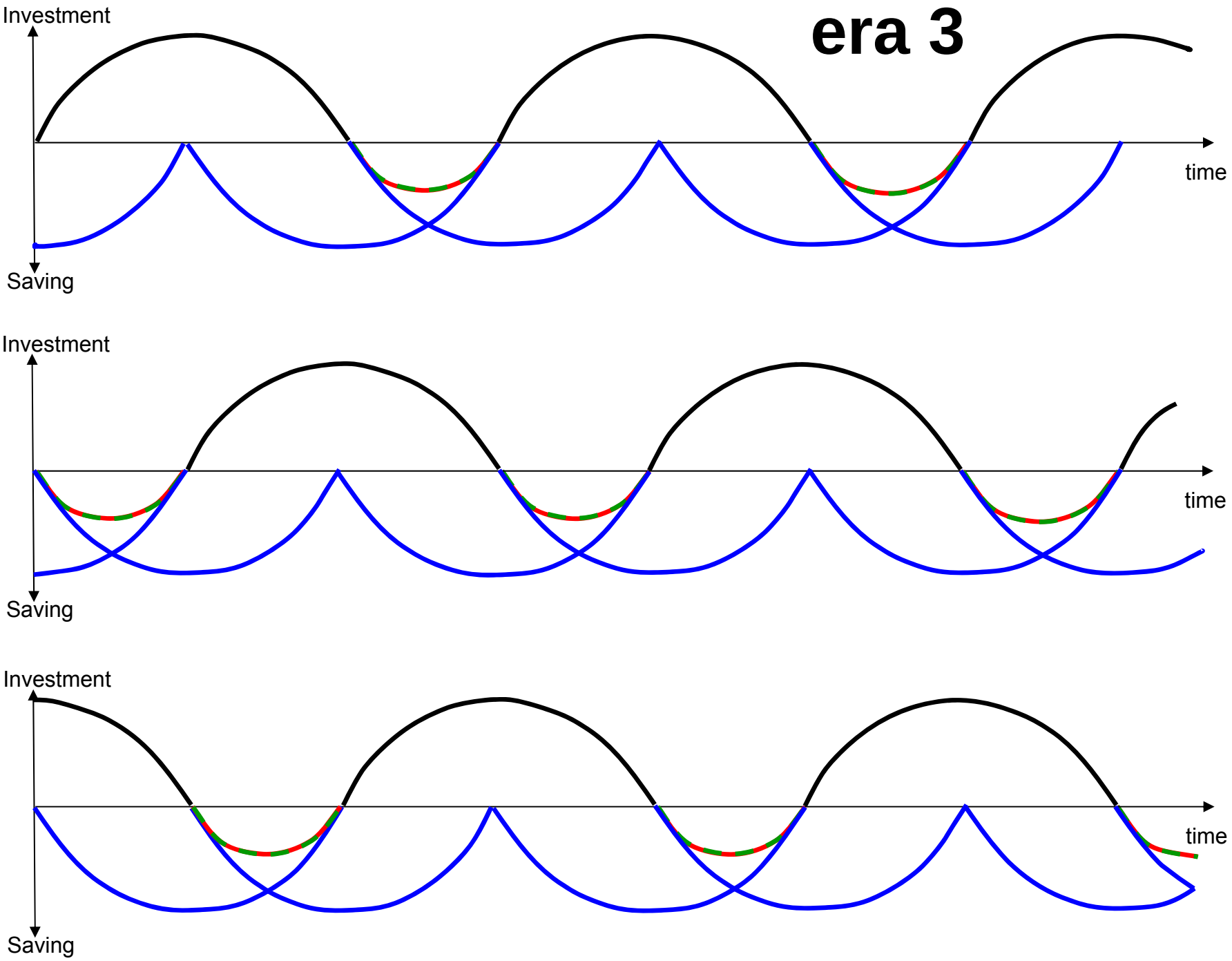


era 3



between projects, agent holds illiquid (blue) paper of different vintages

$\Rightarrow$ great weight on paper markets


era 3
Investment
time
Saving
Investment
time
Saving
Investment
time
Saving

era 3 is a nice example of the power of Adam Smith's "invisible hand":

to create double-coincidences-of-wants in dated goods,

to wriggle round the inflexibility of illiquid paper

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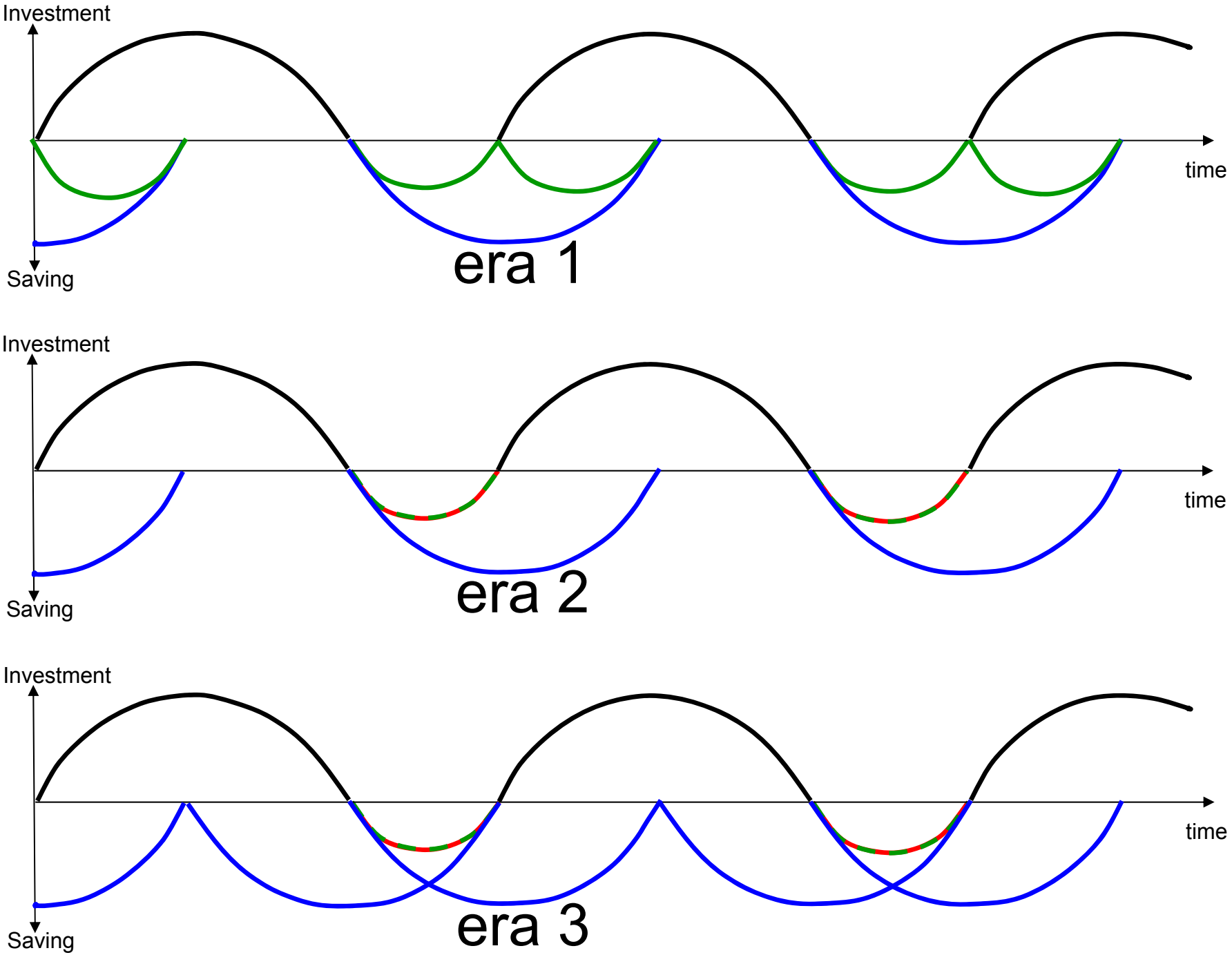
to create double-coincidences-of-wants in dated goods,

to wriggle round the inflexibility of illiquid paper

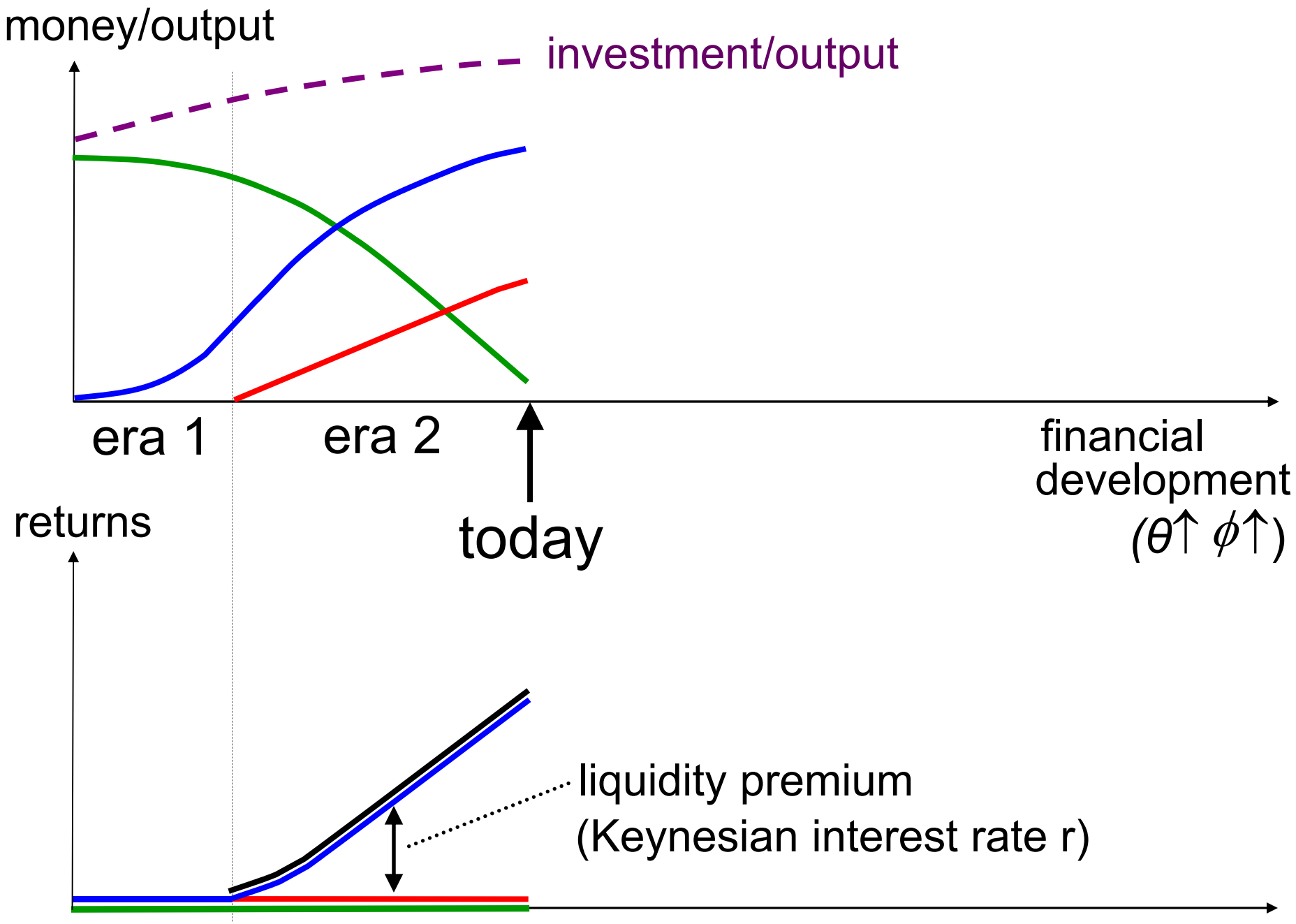
indeed, with enough trust (θ close to 1), first-best is achieved

(in the limit $\theta = 1$, Arrow-Debreu)

overview of the 3 eras:

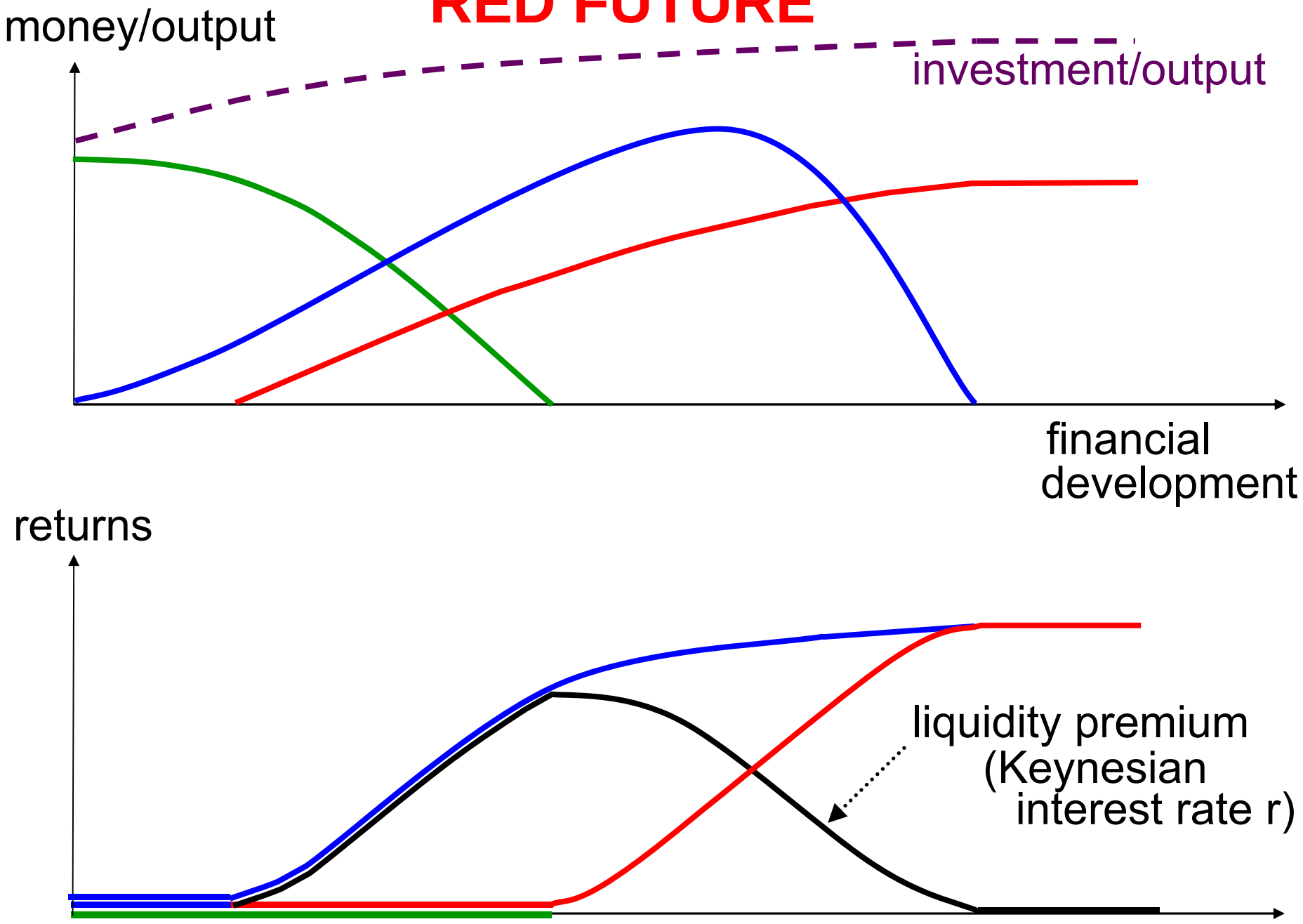

Investment
time
Saving
era 1
Investment
time
Saving
era 2
Investment
time
Saving
era 3

back to the history of money:


money/output
investment/output
era 1
era 2
today
financial
development
(θ↑ ϕ↑)
returns
liquidity premium
(Keynesian interest rate r)

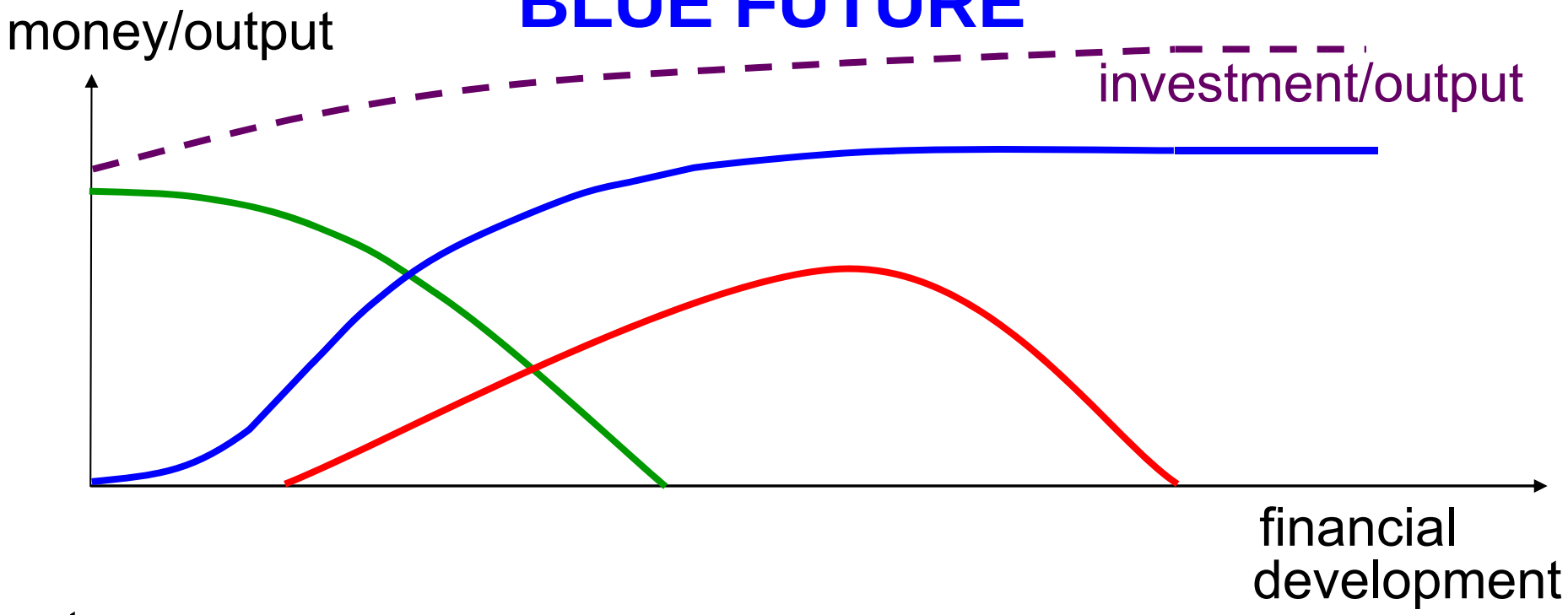
and now, the RED FUTURE:

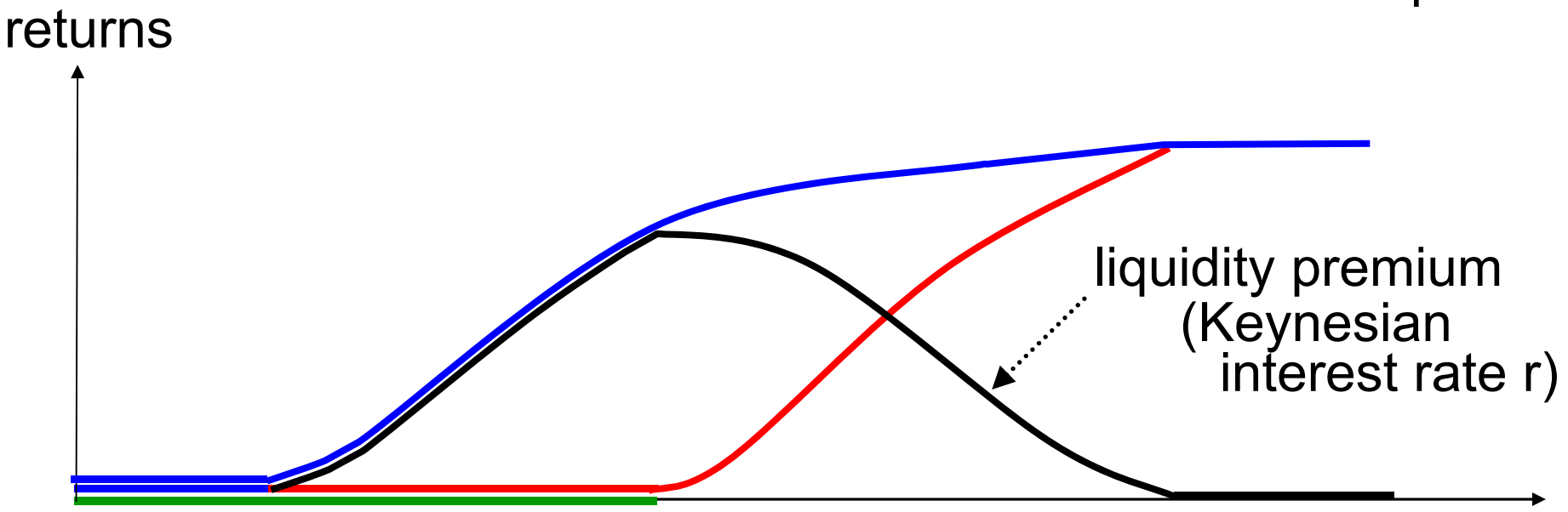
RED FUTURE


money/output
investment/output
financial development
returns
liquidity premium (Keynesian interest rate r)

next, the BLUE FUTURE:

BLUE FUTURE


money/output
investment/output
financial
development


returns
liquidity premium
(Keynesian
interest rate r)